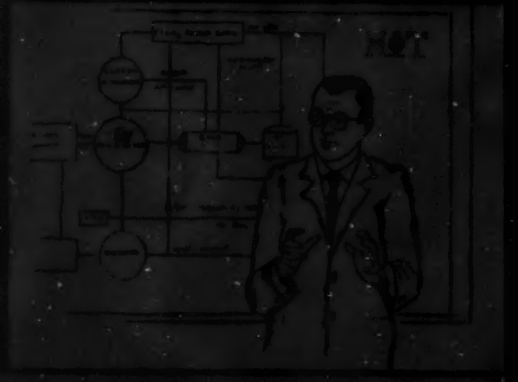
DECEMBER • 1956

NLGI Spokesman

Journal of National Lubricating Grease Institute



Industry Conclave . . . Pages 9-17

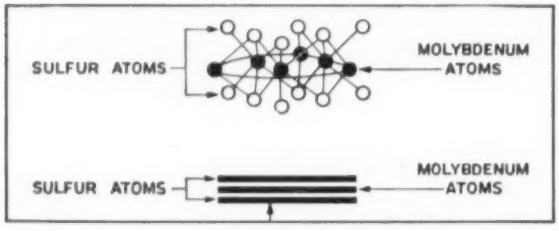
Effective lubrication of torsion suspension bushings of heavy duty trailers has been a maintenance problem with many truckers. The bushing at the left was removed still in good condition after 160,000 miles of service. This bushing was lubricated with a chassis grease containing Moly-Sulfide additive. The bushing at the right, lubricated with ordinary chassis grease, needed replacement after 35,000 miles of service.

How Moly-Sulfide additives EXTEND EFFECTIVE LUBRICATION

Why Moly-Sulfide additives are used in lubricants by trucking fleet operators, railroads, aircraft and automotive manufacturers, oil well drillers and steel mills.

Moly-Sulfide has six characteristics which make it an ideal lubricant additive wherever mechanical action wipes or shears off the hydrodynamic film.

1. Because of its affinity for metals, Moly-Sulfide readily forms a film on metal surfaces.
2. Moly-Sulfide has a low coefficient of friction.
3. It has a high factor of durability.
4. Moly-Sulfide has a thermal stability of −100°F. to +750°F.
5. It has a high chemical resistance to acids, alkalis and water.
6. It withstands high pressures, having a low shear strength and a high film strength.

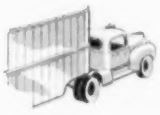


Above, structural diagram of the Moly-Sulfide molecule. Below is a functional illustration of the laminar structure. Each lamina is composed of a layer of molybdenum atoms with a layer of sulfur atoms on each side.

What is Moly-Sulfide and how does it function in lubrication?

Mined in Colorado as molybdenite, purified Moly-Sulfide is a lead-grey material. It has a laminar molecular structure, with the Moly atoms sandwiched between layers of sulfur. (See illustration.) The sulfur atoms have an affinity for metal and

bond readily to metal surfaces, giving the film a *low shear strength*. This affinity is caused by a strong intermolecular bond between sulfur and metal. The lubrication results from the easy slippage of sulfur-to-sulfur atoms. As an additive to lubricants, the *Moly-Sulfide will readily form a film and when a grease or oil film is wiped away or sheared off, the Moly-Sulfide film sustains lubrication until a petroleum film reforms.*



Truck and passenger car builders and operators are making wide use of Moly-Sulfide greases for difficult lubrication jobs.

Lubricants containing Moly-Sulfide additive have over 30 established uses in the automotive, aircraft, railroad, oil drilling and steel industries.

Since Abraham Lincoln's time, railroads have been faced with a serious, recurring, *expensive* problem: hotboxes. Right now more than 14 million journal bearings are carrying heavy loads at high speeds on American railroads. These railroads have to deal with an average of 183,000 hotboxes a year at a cost of some $90,000,000.

Initial field tests by at least three leading railroads have shown hotboxes can be reduced materially by the use of grease containing Moly-Sulfide. A way has been devised to apply greases containing Moly-Sulfide on the journals of railroad equipment. This application is supplemental to the oil waste system and as a result the Moly-Sulfide films that are formed sustain lubrication until the oil film is reestablished.

American automobile and truck manufacturers and their customers are now using lubricants containing Moly-Sulfide additive in at least 14 different applications. These include chassis points, ball joint suspensions, torsion suspension assemblies, fifth wheels, shackle bolts, king pins, valve stems, automatic window mechanisms, wind-shield wiper mechanisms, seat adjusters, drive shaft splines.

In aircraft, Moly-Sulfide is added to aircraft greases. In jet engines under exacting conditions of temperature and pressure it is used on turbine shaft splines and gear reduction units.

In other industries, Moly-Sulfide is being used in lubrication jobs which formerly presented serious difficulties. A Florida cement plant is using gear compound containing Moly-Sulfide to lubricate rack gears and a Michigan manufacturer uses Moly-Sulfide as an additive to drawing compounds for drawing stainless steel hub caps. In New York a baker of crackers and cookies is using Moly-Sulfide grease for lubrication of oven chains which must operate at high temperatures. In Louisiana an oil well drilling contractor is using Moly-Sulfide additive in tool joint compounds. He reports that disjointing when drilling below 15,000 feet is no problem now: no galling, welding or stripped threads.

Aircraft manufacturers are using Moly-Sulfide greases on many types of ball and joint suspension lubrication.

Oil well drilling contractors are using Moly-Sulfide additives to tool joint compounds.

Lubrication engineers are offered information and help in evaluating the use of Moly-Sulfide as an additive to lubricants by the Climax Molybdenum Co.

Currently Moly-Sulfide is being investigated by many petroleum research laboratories and lubricant users. They are interested in studying, under practical working conditions, the ability of Moly-Sulfide to increase effective lubrication.

If insuring effective lubrication is a problem facing your company, Moly-Sulfide additives may be a solution. Climax Molybdenum Company is the principal source of this product. If you need authoritative information, please get in touch with us and we will be pleased to send you literature on Moly-Sulfide and the sources of supply for experimental lubricants containing Moly-Sulfide.

Department 58
CLIMAX MOLYBDENUM COMPANY
500 Fifth Avenue, New York 36, N. Y.

Please send me the following:

Literature
1. "Moly-Sulfide, Lubricant Additive" ☐
2. "Moly-Sulfide in Chassis Grease" ☐
3. "Moly-Sulfide Specification and Properties" ☐

List of Sources for
1. Railroad Greases ☐
2. Chassis Greases ☐

Sample — One-ounce tube of Moly-Sulfide ☐

Name .....

Position .....

Company .....

Address .....

CLIMAX MOLYBDENUM

President's page

by J. W. LANE, President, NLGI

CHRISTMAS 1956

As we approach another
Christmas season
our thoughts turn more than ever
to the joys of close family
relationships, how much we have
to be thankful for, and what pleasure
we derive from doing things for others.

May the joy that comes from
thoughtfulness of others,
so much a part of the true spirit
of Christmas, be with each
of us . . . not only during
this present season but
throughout the years that lie ahead.

J. W. Lane

STAYS
ON THE JOB

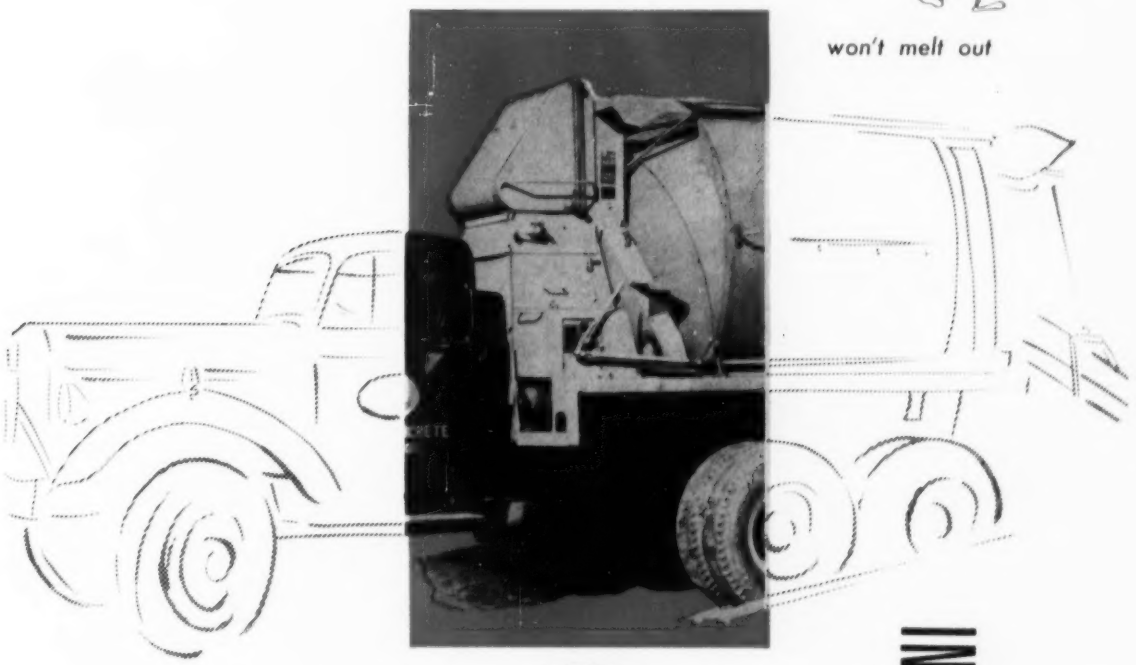
won't wash out

won't squeeze out

won't melt out

International's **INLUCITE 21** is a multi-purpose, lithium-base grease that *outlasts every specialized grease it replaces.* Outlasts ordinary multi-purpose greases, too, bringing longer life to wheel bearings, water pumps, universal joints, shackles and other grease-lubricated bearings.

There is only one **INLUCITE 21.**



INTERNATIONAL LUBRICATION

INLUCITE 21

For details, write

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NEW ORLEANS, LOUISIANA

Manufacturers of Quality Lubricants • AVIATION • INDUSTRIAL • AUTOMOTIVE • MARINE

With Research Comes Quality, With Quality Comes Leadership

Season's Greetings and best wishes for the New Year

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WITCO CHEMICAL COMPANY

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Associated Companies:

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Continental Carbon Company
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NLGI Spokesman

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ABOUT THE COVER

JOHN W. LANE, featured on the cover, is NLGI's 24th president, and will serve through 1957. He is also Socony Mobil's manager of the lubricating department, automotive division.

The top panel illustrates Lane's concern, during his entire career, with furthering the petroleum industry, especially in the automotive field. Lane joined Socony Mobil's New England division in 1934 as an automotive engineer and later became division chief automotive engineer. In 1939 he was transferred to company headquarters in New York and in 1947 was made manager of the automotive division.

Lane has given generously of his time to support organizations across the country and in the middle panel he might be discussing meetings for the New England section of the Society of Automotive Engineers, which he has chairmanned, the American Transit Association, or NLGI.

The bottom panel represents Lane's accomplishments in education. He received both his bachelor's and master's degrees in science from Massachusetts Institute of Technology, and instructed there from 1931 to 1934.

PROTECTION is our business, too

Just as the "everyday" heroes of our nation's Coast Guard risk *their* lives to protect *our* lives—Jones & Laughlin Steel Containers protect your products by providing dependable packaging that assures safety in transportation and storage. Precise fabrication provides accuracy in all fittings and closures.

J&L drums and pails are chemically cleaned and dried by the JaLizing process. This assures a clean and dry, rust-inhibiting surface and increases the adherence and durability of decoration and interior lining.

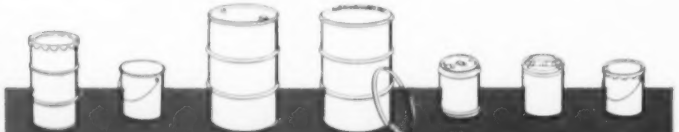
Special protective interior linings are available to provide the best possible packaging for your products.

Jal-Coat, J&L's lithographing process, applies your trademark and sales message to the finished container . . . *no side seam touch-up is ever required.*

Plants located at Atlanta, Ga.; Bayonne, N. J.; Cleveland, Ohio; Kansas City, Kansas; Lancaster, Pa.; New Orleans, La., Philadelphia, Pa.; Port Arthur, Texas; and Toledo, Ohio.

Jal-Coat, J&L's exclusive color lithographing process, adds sales appeal to your products.

J&L STEEL



Jones & Laughlin
STEEL CORPORATION · PITTSBURGH

CONTAINER DIVISION
405 LEXINGTON AVE., NEW YORK 17, N.Y.

NLGI '56

24th annual meeting in october is another successful

INDUSTRY CONCLAVE

NLGI'S 24th annual meeting in Chicago, October 22-24, was another in a series of successful gatherings . . . a utilitarian session at the Edgewater Beach hotel, by a cooperative organization devoted to improving the lubricating grease industry. The three days highlighted the Institute's increasing programs of service and public relations. In the words of Immediate Past President W. M. Murray, who opened the meeting, " . . . too little publicity is given to the merit of lubricating greases, and in this statement I am simply voicing the opinion of the majority of my fellows. In complete realization of our position we plan to do something about it." From the reports of the technical sub-committees, the papers presented, and the give-and-take during the meetings a great deal of continuity and communication were established, knowledge was advanced, and another year of achievement totalled. W. M. Murray summed it up as a " . . . year of work and responsibility . . . an even brighter future is indicated." Following are some 1956 scenes.

SIDE benefit of an NLGI annual meeting . . . the informal discussions between sessions.

NLGI '56

"Grease making is an art," said W. M. Murray, 1956 NLGI president, opening the annual meeting. In welcoming members and guests he pointed out that the past year had been a successful one in the exchange of ideas and information to perfect the art, and to provide the consumer with a better product. More members are active in projects, there are more members and services, and prospects are bright for the industry, he noted. Murray stressed that member companies should continue to have their best personnel represent them in the Institute, so that NLGI ". . . will continue to be successful as one of America's outstanding groups."

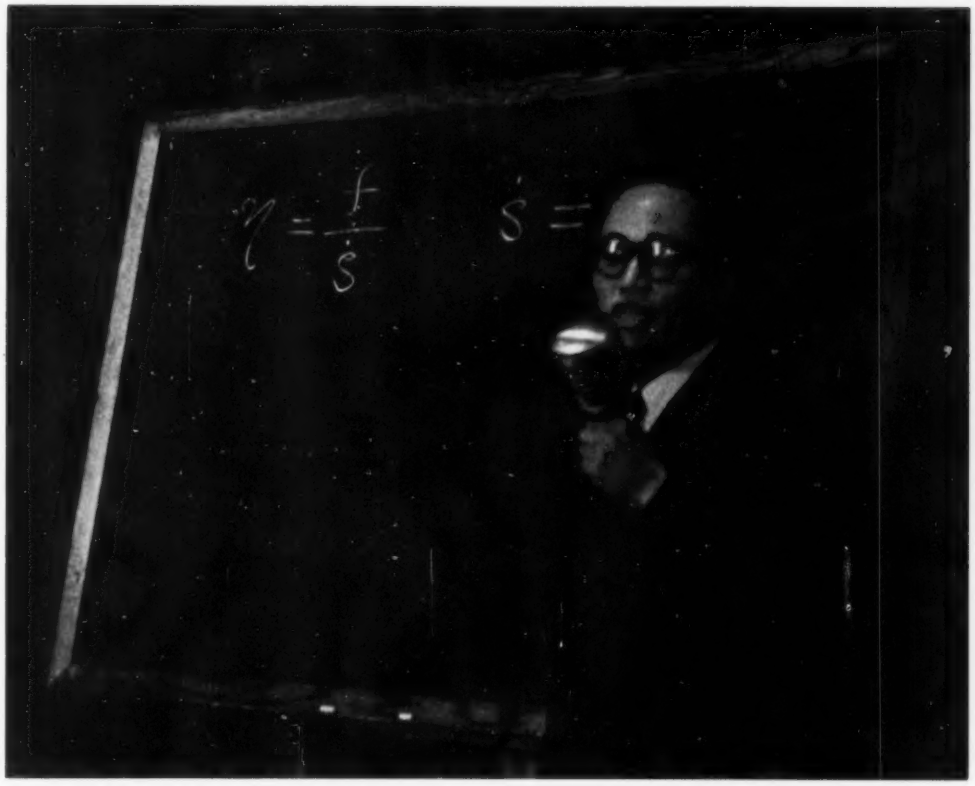
1956 President W. M. Murray opened the annual meeting.

RAY ASHWORTH
Northwestern University

J. V. STARR
Esso Standard Oil Company

M. C. GOODWIN
General Motors Corporation

ENTHUSIASTIC AUDIENCE
Participant Joins in Discussion



RESEARCH fellow Sang Joon Hahn made a brief report of the studies he is conducting.

P. V. TOFFOLI, JR.
Pure Oil Company

T. G. ROEHNER
Socony Mobil Oil Company, Inc.

The National Lubricating Grease Institute sponsors a research fellowship at the University of Utah in Salt Lake City, under Dr. Henry Eyring, dean of the graduate school. Sang Joon Hahn is currently studying under this fellowship in the school's department of chemistry. As a visitor to the meeting in Chicago, he made a brief report to the membership, which included a review of the objectives of his work in the rheological field that he began last July. Other reports made during the three-day session included progress on the forthcoming NLGI movie, "Grease, the Magic Film" and current efforts by the various technical committees.

PANEL chairman Dr. J. V. Starr and the highway safety discussion group.

The product of many minds and many hands, an NLGI annual meeting is actually a seminar where the industry can gather to chart the progress of lubricating grease. Extensive preparation for the next October session begins even before the last gavel tap has concluded the current gathering, and speakers are recruited to present material on a number of subjects interesting to the membership . . . a successful pattern that pays off for all that work, with the meeting attendance totals climbing higher every year.

NLGI '56

H. L. LELAND
Esso Research & Engineering Co.

A. A. SCHWARTZ
General Electric Company

J. L. DREHER
California Research Corporation

H. A. WOODS
Shell Oil Company

R. CUBICCIOTTI
L. Sonneborn & Sons

J. H. FLANAGAN
Standard Oil Company of Indiana

A. S. RANDAK
Sinclair Refining Company

C. E. GORE
Battenfeld Grease & Oil Corporation

MARKETING symposium chairman Cubicciotti and participants.

Panels, questions and answers, discussion, papers for study afterwards . . . the Grease Institute's 24th annual meeting sends the attendee back with a great deal of information about his product. New developments, products, applications, it's all there, along with the contacts and friendships that have grown up over the years. The two and a half days are essential to, as one member puts it, ". . . just keep in touch."

W. A. MAGIE II
Magie Bros. Oil Company

J. E. SIMONDS
Esso Standard Oil Company

H. K. GANDELOT
General Motors Corporation

E. E. SMITH
Climax Molybdenum

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G. ENTWISTLE
Sinclair Refining

D. F. RHODES
Canadian Oil Company, Ltd.

H. SCHWENKER
Wright Air Development Center

E. W. NELSON
Continental Oil Company

INCOMING president, J. W. Lane

QUESTIONS and answers following one presentation.

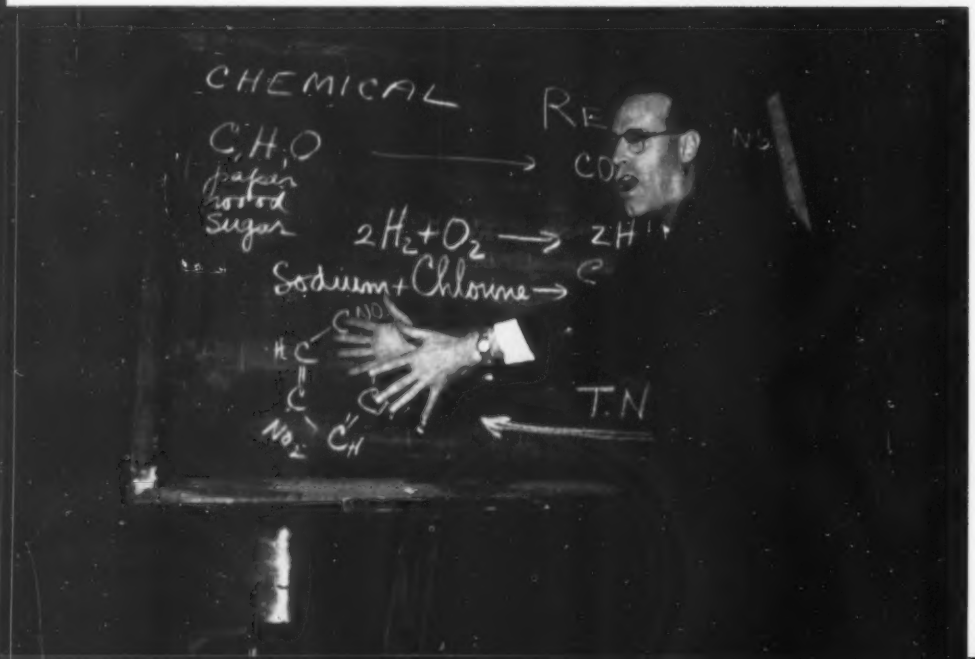
NL GI '56

PRINCETON S Professor Alyea demonstrates.

Atomic Energy- Weapon for Peace

For more than two hours, Princeton's Professor H. M. Alyea held the NLGI banquet audience enthralled with a rapid-fire explanation, demonstration and chemical exposition for the atom as a weapon for peace. The untiring professor projected the possibilities for miracles of the atom undreamed of even a few years ago.

CONSTANT action, commentary and display.



by
H. N. Alyea
Frick Chemical Laboratory

NLGI's
Banquet
Speaker
24th Annual Meeting

NLGI '56

TRIBUNE'S Inquiring Reporter talks to G. A. Olsen.

WGN-TV, Chicago, interviewed Murray during meeting.

PRESENTATION of tray to Chittick by Murray.

Some five times the National Lubricating Grease Institute has honored men of the industry and the term of contribution considered goes back to the founding of the Institute, in 1933. The NLGI award, an engraved silver tray, was presented at the 24th annual meeting in Chicago to Col. Martin B. Chittick and the ceremonial presentation remarks best tell why the membership honored this leader:

"The recipient tonight is a distinguished former president of the Institute . . . in fact, it's second president and one of the organizers of NLGI. This gentleman served as chairman of the technical committee and developed the lubricating grease classification now used internationally . . . a great deal of work, which has contributed mightily to Institute successes.

"This citation is an indication of the high regard of associates in the industry for his accomplishments and contributions."

Colonel Chittick is associated with the American Mineral Spirits company. ■

FUTURE MEETINGS of the Industry

DECEMBER, 1956

3-4 New Mexico Oil & Gas Association (annual meeting), Alvarado Hotel, Albuquerque.

4-5 Petroleum Packaging Committee, Hotel DeSoto, Savannah, Georgia.

5-6 The Asphalt Institute (annual meeting), Site unselected.

6-8 Oil Industry Information Committee, Biltmore Hotel, New York City.

16-18 Kansas Independent Oil & Gas Association (annual meeting), Broadview Hotel, Wichita.

JANUARY, 1957

8-10 Kentucky Petroleum Marketers Association (annual meeting), Brown Hotel, Louisville.

17-18 National Industrial Conference Board (general session), Hotel Commodore, New York City.

21-25 American Institute of Electrical Engineers (1957 Winter general meeting), Hotel Statler, New York City.

23-24 Northwest Petroleum Association, Nicollet Hotel, Minneapolis.

FEBRUARY, 1957

8-9 Symposium on Composition of Petroleum Oil ASTM (Committee D-2), Jung Hotel, New Orleans.

22 Natural Gasoline Association of America (Permian basin regional meeting), Scharbauer Hotel, Midland, Texas.

24-28 AIME Annual Meeting, Hotels Roosevelt and Jung, New Orleans.

26-27 API Division of Marketing (Lubrication Committee), Sheraton-Cadillac Hotel, Detroit.

MARCH, 1957

11-12 Illinois Petroleum Marketers Association (35th annual convention), Hotel Pere Marquette, Peoria, Ill.

14-16 Texas Oil Jobbers Association (annual convention), Rice Hotel, Houston.

19-21 Ohio Petroleum Marketers Association (Spring convention and trade exposition), Deshler-Hilton Hotel, Columbus.

20-22 API Division of Production (Southern District meeting), Washington Youree & Captain Shreve Hotels, Shreveport.

25-27 Midwest Gas Association meeting, Hotel Nicollet, Minneapolis.

27-29 American Power Conference meeting, Sherman Hotel, Chicago.

28 National Industrial Conference Board (general session), Sheraton-Palace Hotel, San Francisco.

APRIL, 1957

7-12 American Chemical Society (131st national meeting), Miami, site unreported.

10-12 API Division of Production (Mid - Continent District meeting), Mayo Hotel, Tulsa.

16-18 National Petroleum Association, Cleveland, Ohio.

18 National Industrial Conference Board (meeting of board), Waldorf - Astoria Hotel, New York City.

24-26 National Gasoline Association of America (36th annual convention), Rice Hotel, Houston.

24-26 API Division of Production (Rocky Mountain District meeting), Gladstone, Townsend & Henning Hotels, Casper, Wyo.

28-30 Independent Petroleum Association of America (midyear meeting), Buena Vista Hotel, Biloxi.

29-May 1 American Oil Chemists' Society (annual meeting), Roosevelt Hotel, New Orleans.

MAY, 1957

1-3 API Division of Production (Eastern District meeting), William Penn Hotel, Pittsburgh.

6-8 API Annual Pipe Line Conference, Cleveland Hotel, Cleveland.

13-16 API Division of Refining (midyear meeting), Sheraton, Hotel, Philadelphia.

15-17 Fuel Oil Distributors Association of New Jersey (annual convention), Hotel Berkeley, Carteret, Asbury Park, N. J.

16-17 National Industrial Conference Board (general session), Waldorf - Astoria Hotel, New York City.

19-22 Texas Independent Producers & Royalty Owners Association (annual meeting), Galvez and Buccaneer Hotels, Galveston.

22-24 API Division of Production (Eastern District meeting), William Penn Hotel, Pittsburgh.

JUNE, 1957

9-14 API Division of Production (midyear committee conference), Muehlebach Hotel, Kansas City.

10-12 Interstate Oil Compact Commission (midyear meeting), Canyon Hotel, Yellowstone National Park.

16-21 ASTM, Chalfonte-Haddon Hall, Atlantic City, N. J.

24-25 Michigan Gas Assn. meeting, Grand Hotel, Mackinac Island, Mich.

24-28 American Institute of Electrical Engineers (1957 Summer general meeting), Sharaton-Mt. Royal Hotel, Montreal.

SEPTEMBER, 1957

11-13 National Petroleum Association (55th annual meeting), Traymore Hotel, Atlantic City, N. Y.

SHELL
ALVANIA GREASE

A TRULY MULTI-PURPOSE LUBRICANT!

. . . Gives you all these savings:

1. **Extends time between greasings**

   Shell Alvania Grease, because of its remarkable mechanical and oxidation stability, stays in the bearings . . . lasts many times longer than conventional greases.

2. **Low-cost applications**

   With just one grease to handle, and with fewer servicings required, costs are reduced substantially.

3. **Simple inventory**

   Shell Alvania Grease replaces as many as 20 special-purpose greases formerly considered necessary for an adequate inventory!

4. **Better protection**

   Shell Alvania Grease contains special corrosion inhibitors to insure bearing protection and good lubrication even under wet operating conditions.

5. **Greater safety**

   Shell Alvania Grease continues to provide adequate lubrication long after most greases have been forced out of the bearings. And there's no chance of applying the wrong grease.

SHELL OIL COMPANY

50 West 50th Street, New York 20, New York
100 Bush Street, San Francisco 6, California

Molybdenum Disulfide as a Grease Additive

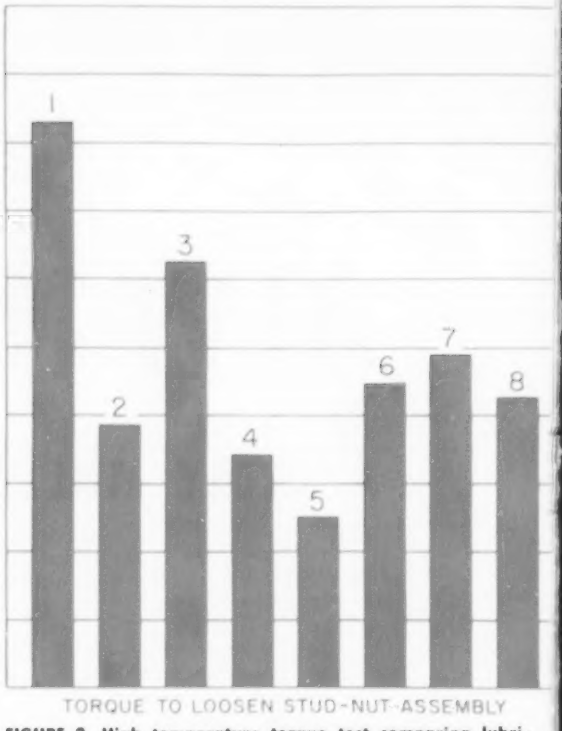


FIGURE 2. High temperature torque test comparing lubricating properties of solid additives under conditions of high temperature and high torque.

THE ADDITION OF various solids for specific improvements has been a common practice in grease manufacture for many years. Examples of commercial greases in which solid additives are used are tool joint grease, curve rail grease, leaf spring grease, drawing compounds, roll-neck bearing grease and API high-pressure thread compound. In general, the function of the solid additive in lubricating grease has been prevention of metal-to-metal contact with consequent reduction of wear in the part under lubrication.

Such solid additives are generally classified into the following:

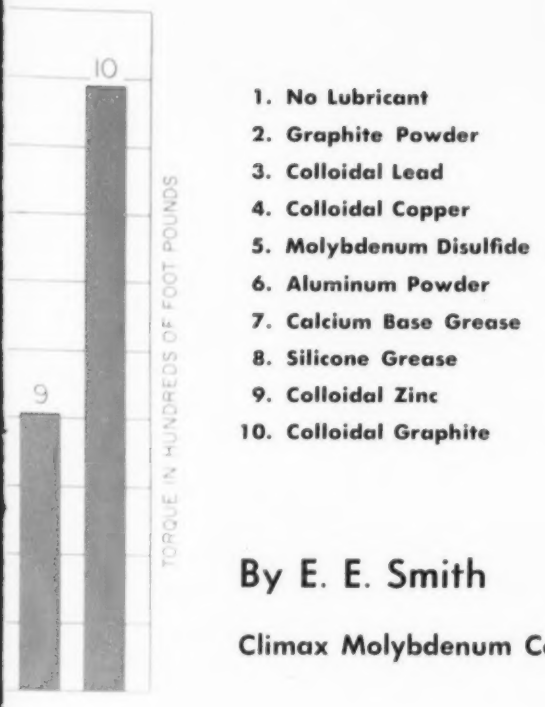
Categories	*Examples*
Carbon	Graphite
Silicates	Vermiculite
Metal Sulfides	Molybdenum Disulfide
Metal Sulfates	Barium Sulfate
Metal Carbonates	Lead Carbonate
Metal Oxides	Zinc Oxide
Metal Powders	Lead Powders

Of these solid additives, molybdenum disulfide is a relative newcomer. It has been the object of much investigation over the past few years, and the understanding of its characteristics has led to a variety of commercial applications for the material both as a dry lubricant and as an additive to specialty greases.

This paper is a progress report on this new development. Most of the new research discussed in this paper was carried out in the research laboratory of the Climax Molybdenum Co. by J. P. Binkelman. It reviews the properties of molybdenum disulfide, compares these properties with those of other solid additives, explains how molybdenum disulfide functions in grease, and reports new data to serve as a guide to the use of molybdenum disulfide as a grease additive.

Properties

The source of molybdenum disulfide is the mineral molybdenite, which is obtained in molybdenum mining as the principal product and in copper mining as a by-product from certain ores. The formula of the material is MoS_2; its molecular weight, 160.08. The pure chemical is blue-gray to black in color, does not melt below 2700 F, has a specific gravity of 4.8 to 5.0, and a hardness of 1 on Mohs scale. It is a chemically stable compound and is insoluble in water, oil, alkalies and all acids with the exception of a few strong oxidizing acids such as aqua regia and concentrated sulfuric acid.



By E. E. Smith

Climax Molybdenum Co.

The lubricating characteristics of molybdenum disulfide are related to its unique laminar structure, which can be seen with the electron microscope. [1] This structure can be likened to a sandwich, with each lamina composed of two layers of sulfur atoms as the "bread" and a layer of molybdenum atoms as the "filling." All the laminae have this same sandwich structure. The atoms in a given lamina are attracted to each other with a greater attractive force than exists between sulfur atoms in different lamina. Thus the bonds between layers are weak relative to the bonds within layers. As a result, one lamina slides easily over the other, imparting low shear characteristics to the compound.

The properties of molybdenum disulfide that are of value in its use as an additive to grease can perhaps best be illustrated by comparing the material with other solid additives commonly used. This has been done in determining its coefficient of friction by means of the press-fit test; its lubricating properities under conditions of high torque and high temperature; its performance in the Shell Four-Ball E. P. test; and its relative abrasivity.

As shown in Figure 1, a molybdenum disulfide-containing grease has a coefficient of friction of 0.104 as compared with 0.132 for graphite grease and 0.214 for zinc oxide grease. These data were obtained by measuring the load required to force a 1.001 in. pin into a 1.000-in. bushing. This procedure gives bearing pressures up to 8400 psi. Tests of other commonly used lubricants or additives are shown for comparison.

The performance of molybdenum disulfide at high temperatures and high torques is shown in Figure 2 in comparison with a number of other solid additives used in such commercial products as tool joint compounds, high pressure thread compounds and roll-neck greases. The value on the graph is the torque in foot pounds necessary to loosen a thoroughly lubricated 1¼ x 7 in. stud-nut assembly after 5000 hours at 1000 F. Under severe test conditions, molybdenum disulfide surpassed colloidal copper, graphite powder, colloidal zinc, and all other compounds tested.

The superiority in extreme-pressure (E.P.) properties of a grease containing 5% (by weight) molybdenum disulfide over the same grease with 5% graphite and a similar grease containing conventional E.P. additives is shown in Figure 3. In this Shell Four-Ball E. P. test, the molybdenum disulfide grease has a mean Hertz load value of 50 as compared with 26 for the graphite grease and 18 for the grease alone. By comparison, the conventional E.P. grease has a value of 34.

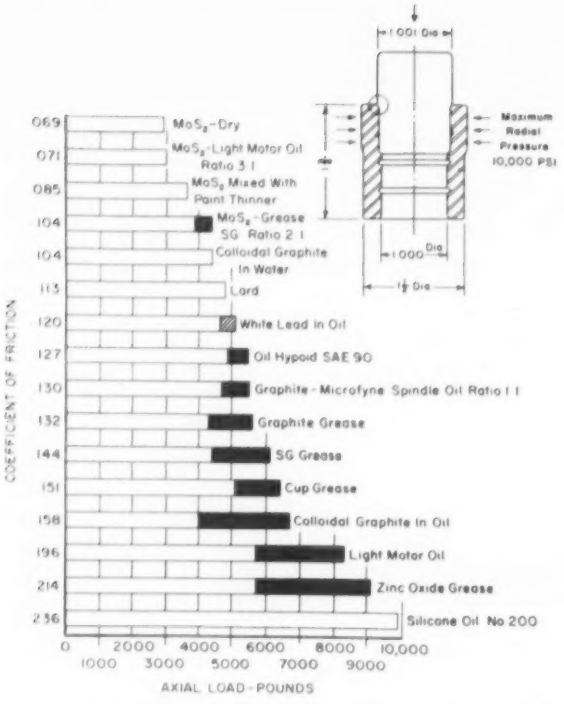
The results obtained in comparing the abrasiveness of molybdenum disulfide and graphite by means of the abrasion tester described in Appendix A are shown in Table I. Both technical molybdenum disulfide and commercially pure molybdenum disulfide are superior to high-purity electric furnace graphite.

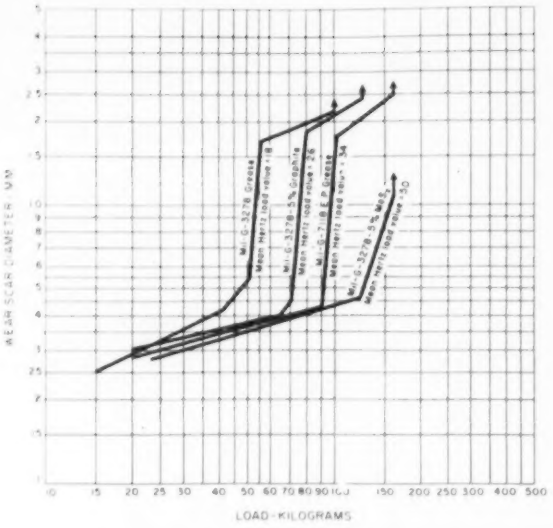
How MoS_2 Functions in Grease

The previous data indicate that molybdenum disulfide has certain advantages over other solid additives commonly used in grease manufacture. In order to apply the advantages of this relatively new additive, it is necessary to learn how it functions. First, molybdenum disulfide deposits out of greases onto metal surfaces to form durable low-friction films.

An ingenious experiment demonstrates the formation of these films. [7] The test involves rotating three bronze sliders in a two-inch circle against a steel plate to form a thrust bearing lubricated with 2.5 grams of a calcium-base grease to which 12% molybdenum disulfide has been added. The bronze sliders are polished with 3/0 emery paper. The plate is SAE 1020 steel with a surface ground finish. The load is 500 psi and the sliding speed 56 rpm. After seven hours of operation, the bearing is disassembled and cleaned free of grease with benzene. The worn surfaces show no visible film of molybdenum disulfide, but X-ray diffraction studies (method described in Appendix B) reveal invisible trace. The data supporting this conclusion appeared in Table II.

Second, films of molybdenum disulfide give significant improvements in lubrication. This is demonstrated by the same procedure used for detecting the presence of the film. First the thrust bearing is operated with 2.5 grams of a cup grease and then with 2.5





Left, FIGURE 1. Press-fit test comparing MoS2 with other oil and grease additives. Bearing pressures up to 8400 psi.

FIGURE 3. Shell four-ball E. P. test comparing effects of 5% additions of graphite and MoS2 to lithium-base grease.

grams of the same cup grease to which 12% molybdenum disulfide has been added. After the bearings are washed in benzene, they are reassembled in the test equipment and operated at various speeds and loads to determine whether there is any difference in their behavior.

Table III indicates the effectiveness of the extremely small quantities of molybdenum disulfide remaining on the bearing after lubrication with the molybdenum disulfide grease.

As the data show Table III, the residual film of molybdenum disulfide gives lower friction at both 133 and 266 psi bearing pressures than plain cup grease. When the pressure was increased to 535 psi, the molybdenum disulfide film prevented seizure.

A more striking demonstration of the effect of these residual films is given by the U.S. Navy 2-hour Falex wear procedure described in Appendix C. The total weight loss of the test specimen (blocks and pins) used in the test are given below.

Navy 2-Hour Falex Wear Test*

Grease	*Loss in Weight of Specimens mg*	
Lithium-Base	1,000	
Lithium-Base plus 2% MoS_2	1.3)	
	1.9)	3 runs
	2.7)	

Formation of MoS_2 films of high durability is also demonstrated by the Timkin endurance procedure described in Appendix D. The results for a lithium grease with and without molybdenum disulfide are

TABLE I

Comparison of the Abrasiveness of Graphite and Molybdenum Disulfide

Test Material	*Weight Loss in 2 hr. mg*
Natural Graphite	
Type 1 (ash 3.75%)	24.5 av.
2 (ash 2.9%)	13.9 av.
5 (ash 6.57%)	150+
High Purity Electric Furnace Graphite	
Type 38 (ash 0.2% max size, min 98.5% −200 mesh)	5.9, 5.9
39 (ash 0.8% max size, min 98.52% −200 mesh)	5.1, 6.5
Molybdenum Disulfide, Technical (Insolubles 0.50%)	0.6, 0.8, 1.4
Molybdenum Disulfide, Pure (Insolubles, 0.18%)	0.16

Tests made in the Abrasion Tester using the Preliminary Testing Procedure described in Appendix A.

TABLE II

X-Ray Diffraction Test for Detection of the Presence of Molybdenum Disulfide

Sample	*Number of Counts Over Background*
Unused paper	0
Paper rubbed against steel bearing plate*	10
Paper rubbed against bronze sliders*	75
Paper rubbed against a steel plate having film of MoS_2 weighing 1.5 Mg./cm²	450

*Lubricated with calcium base grease containing 12% MoS_2 in thrust bearing described in Appendix B.

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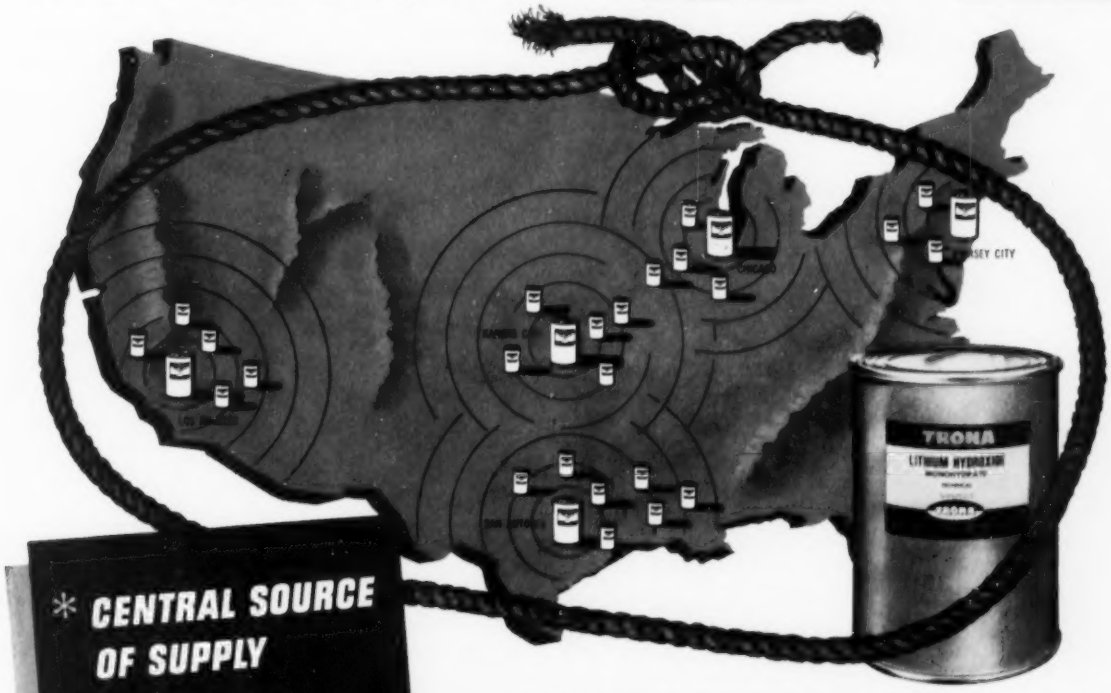

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TABLE III

Lubricating Effect of Residual Traces of MoS_2 After Removal of Lubricant

Bearing Pressure and Sliding Speed During Successive 10-minute Periods		*Coefficient of Friction*	
		Cup Grease	*Cup Grease plus 12% MoS_2*
133 psi	6 fpm	.157	.142
133	13	.171	.136
133	56	.177	.136
256	56	.163	.058
535	56	seized and stalled	chattered but continued operating

shown in Figure 4. Grease No 4, containing 3% MoS_2 is comparable to a commercial E.P. grease. The extended operation of the test ring at greatly reduced temperatures demonstrates the formation of durable MoS_2 films and the protection they afford. It is clear, too, that addition of only 1.5% MoS_2 to a lithium multipurpose grease results in marked improvement but the protection is neither as great nor as long-lasting as the addition of 3% MoS_2.

Variables Affecting Performance of MoS_2 in Grease

The conclusion may be drawn from these test data that the percentage of MoS_2 added determines performance of the additive in a grease. This, of course, is an obvious variable. Other variables are the type of soap, the viscosity of the contained oil and the particle size of the molybdenum disulfide. A series of tests has been conducted to evaluate the effect of these different variables.

In this study a series of greases containing various soap bases and mineral oils of selected viscosities were evaluated by four laboratory standard lubrication tests:

(1) The Timken load capacity test
(2) The Falex load capacity test
(3) The Timkin film endurance test
(4) The Falex film endurance test.

To each of the greases 3% MoS_2 was added, and the same tests were then repeated to obtain an evaluation of the improvement in properties effected by MoS_2. To provide a basic for the evaluation, data for these test greases were compared with some commercial greases. A description of the test greases is given in Table IV. Test procedures are given in Appendixes D, E, F, G.

Results of these varying tests are given in Figures 4 through 8 and Tables V through VIII. They are summarized in Table IX. *Before detailed discussion of these results, it should be emphasized that test machines such as the Timken and Falex were used merely as laboratory research tools. No conclusions as to the E.P. properties of the test samples should be made from values obtained in these tests run primarily to determine the effects of composition.*

Type of Soap

It is evident from the data that the different types of soap cause greases to vary in their susceptibility to improvement by addition of MoS_2. Of those tested, two stand out as good base soaps for MoS_2 film formation. In No. 4 grease, 5% lithium 12-hydroxystearate was compounded with an oil of viscosity 537 SUS @ 100 F and 3% MoS_2. This grease gives a Timken O.K. load of 12, a Falex load of 500, Timken endurance of over 530 minutes and Falex endurance of 6.8 minutes.

In grease No. 6, 8% calcium soap was compounded with an oil of viscosity of 537 SUS @ 100 F plus 3% MoS_2. This grease gives a Timken O.K. load of 12, a Falex load of 750, Timken endurance of 73 minutes and Falex endurance of 6.5 minutes.

Incidentally, both of these compare favorably with a conventional E.P. grease, No. 4B. This grease has a Timken O.K. load of 16, a Falex load of 500, Timken endurance of 450 minutes and Falex endurance of 8.5 minutes.

Per Cent of MoS_2

The variation in performance of a grease containing different percentages of MoS_2 is shown in Figure 6, 7 and 8. The endurance of the MoS_2 film is shown by Timken tests (Figure 7), indicates that 3% MoS_2

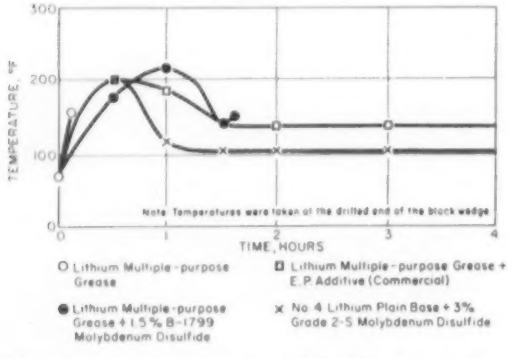

FIGURE 4. Bearing run-in and film formation as seen from running temperature in timken endurance tests.

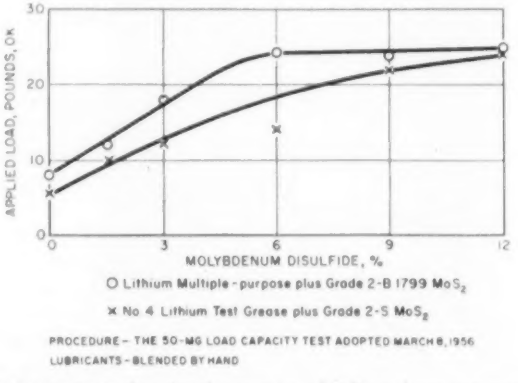

FIGURE 5. Timken load capacity of lithium base greases with and without addition of micronized MoS2.

TABLE IV

Description of the Lubricants Tested

Grease Number	Soap or Thickener Type	Wt. %	Mineral Oil SUS 100 F	SUS 210 F	VI	ASTM Penetration Unw.	W.	NLGI Grade	ASTM Drop Point
1	Lithium Soap*	9.4	106	40	94	274	267	2	379 F
2	Lithium Soap*	11.0	537	65	95	278	266	2	390 F
3	Lithium Soap*	11.0	982	86	93	282	274	2	391 F
4	Lithium Soap*	5.0	537	65	95	366	359	0	384 F
5	Sodium Soap	10.0	537	65	95	270	275	2	372 F
6	Calcium Soap	8.0	537	65	95	295	280	2	300 F
7	Aluminum Soap	10.0	537	65	95	264	283	2	246 F
8	Clay Microgel	4.8	537	65	95	259	265	2	none
			Commercial Greases						
5212	Lithium Soap*	9.5	519	59	65	277	275	2	365 F
5242	Clay Microgel	4.8	537	65	95	274	286	2	none
4C	Lithium Multi-Purpose	5.0	80						
4B	Lithium Multi-Purpose–E. P. Additive								
4A	Lithium H-1								
			Molybdenum Disulfide–Technical						
	2-S pulverized by Sturtevant, also known as (71-G)								
	Av. Particle Size 1/2 micron								
	Insolubles 0.50%								

*12 Hydroxy stearate.

is the minimum amount needed for best performance. Above this percentage, further addition of MoS_2 do not increase life of the film. With the lower-speed Falex test, however, the increase in film life is directly proportional to the percentage of MoS_2 up to the highest percentages used (Figure 8).

In evaluating the load capacity as a function of the amount of MoS_2 in the grease, the Timken tests (Figure 5) show an improvement as the MoS_2 content is increased from 0 to 6%. Load capacity determined by the Falex Test (Figure 6) also levels off at about 6% MoS_2 addition. Analysis of the data indicates that at least 2% MoS_2 is needed for film formation, and that at least 3% is needed for appreciable improvement.

Viscosity of Contained Oil

Three of the test procedures used on the plain lithium-base greases show that film strength increases with the viscosity of the contained mineral oil as indicated in Table IV and Figure 9. The upper graph of Figure 9 gives the film strength of four lithium-base greases without MoS_2 at varying viscosities of the contained oil, while the lower graph shows the increase in film strength imparted to the same greases by 3% MoS_2 additions plotted against the viscosity of the contained oil. Film strength increases with the addition of MoS_2 but the percentage increase is greater when the contained oil is of lower viscosity.

The reason for the falling off in the effectiveness of

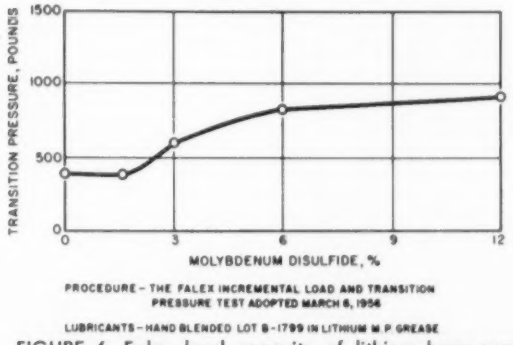

FIGURE 6. Falex load capacity of lithium base grease with and without addition of micronized MoS2.

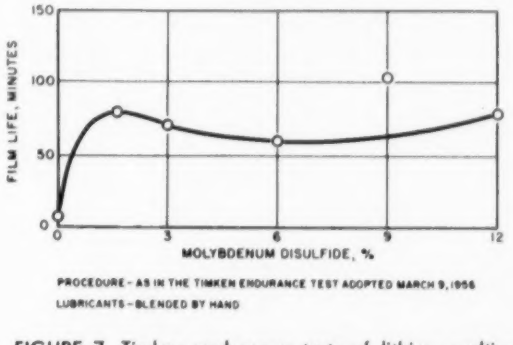

FIGURE 7. Timken endurance tests of lithium multi-purpose grease with and without B-1799 micronized MoS2.

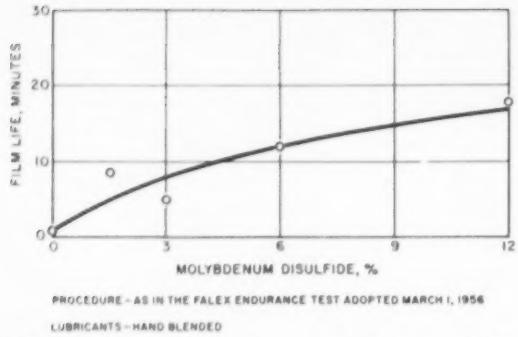

FIGURE 8. Falex film endurance of lithium multi-purpose grease with and without B-1799 micronized MoS2.

MoS_2 with higher viscosity oil is that MoS_2 additions thicken the grease and render the flow characteristics less ideal for film formation. The formulator may find that it is necessary to use greases with lower viscosity oils, to obtain the desired improvement with MoS_2 in a given application.

As already mentioned, additions of more than 3% MoS_2 do not improve film life as determined in the Timken endurance test (Figure 7). Perhaps this is another indication of the necessity to use oils of lower viscosity in grease formulations containing high percentages of MoS_2.

In these data (Table IX), the effect of the percentage of base soap is also apparent, although it is somewhat hidden by the more pronounced effect of oil viscosity. In the results for greases 2 and 4, where the oil viscosity is the same, the 5% soap mixture is definitely superior to the 11%. In grease 3, the high oil viscosity and the high percentage of soap produced an adverse effect on MoS_2 film formation, as can be seen in the load capacity test.

Effect of Particle Size

In a different series of tests, it was determined that fine-particle-size MoS_2 is more effective than coarse material in filming out of grease. Here too, the results

TABLE V

Timken Load Capacity of the Test Greases With and Without Addition of 3% Lot 2-S MoS_2

Grease Number	*Applied Load, Pounds, O.K.* *Grease Without MoS_2*	*Grease With MoS_2*
1	<1	5
2	5	10
3	10	10
4	6	12
5	6	12
6	8	12
7	6	6
8	8	10
5212	6	8
5242	10	8
4C	8	16

TABLE VI

Falex Load Capacity of the Test Greases With and Without 3% Lot 2-S MoS_2

Grease Number	*Transition Pressure, Pounds* *Greases Without MoS_2* *Tests*		*Average*	*Greases With MoS_2* *Tests*		*Average*
1	100	100	100	300+	300+	325
2	300	300	300	400+	400+	425
3	400	400	400	400−	300+	350
4	300	400−	375	500	500	500
5	500	500	500	400+	400+	450
6	600−	600−	575	800−	700+	750
7	300+	300−	350	500	400	450
8	400+	500−	450	600	500+	550
5212	300+	300+	325	400+	500−	450
5242	400+	500−	450	500−	400+	450
4C	400+	400+	425	400+	400+	425
4A	400	400	400	500	400+	450
4B				800	700+	775

TABLE VII

Timken Film Endurance of Test Greases With and Without Addition of 3% Lot 2-S Micronized MoS_2

Grease Number	*Film Life, Minutes* *Grease Without MoS_2*	*Grease + MoS_2* *Run 1*	*Run 2*	*Average*
1	0	0	0	0
2	0.7	20	28	24
3	2.0	4	75	40
4	0	300+	760+	530+
5	13.0	60	90	75
6	0	65	80	73
7	6.0	3	9	6
8	3.0			
5212	1.5	45	40	43
5242	30.0	7	28	18
4B		450		450
4C	8.0			

TABLE VIII

Falex Film Endurance of the Test Greases With and Without 3% Lot 2-S MoS_2

Grease Number	*Film Life, Minutes* *Greases Without MoS_2* *Tests*		*Average*	*Greases With MoS_2* *Tests*		*Average*
1	0.2	0.2	0.2	2.6	1.5	2.1
2	0.75	1.0	0.87	2.7	3.1	2.9
3	1.5	1.7	1.6	3.7	2.7	3.2
4	0.8	1.2	1.0	7.8	5.7	6.8
5	1.5	2.5	2.0	1.7	1.0	1.4
6	3.6	3.5	3.55	6.5	6.5	6.5
7	2.0	4.0	3.0	1.0	1.0	1.0
8	4.0	5.0	4.5	4.5	4.7	4.6
5212	0.75	1.1	0.92	1.3	2.1	1.7
5242	4.0	4.0	4.0	5.7	6.5	6.1
4C	1.0	1.0	1.0	9.5	9.3	9.4
4A	1.7	1.1	1.4	5.0	7.0	6.0
4B				7.0	9.9	8.5

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were obtained on Timken and Falex test machines. As Table X shows, the fine-particle-size material (average particle size one-half micron) forms superior films. The results may be used as a guide in formulating greases containing MoS_2 for specific purposes. Now let us take a look at results of other tests that more nearly simulate actual service conditions.

TABLE X

Effects of MoS_2 Particle Size on Film Formation

TIMKEN TESTS

Lubricant	*OK Load, lb.*	*Score Load, lb.*
Grease alone	7	8
Grease plus 10% MoS_2 (Average particle size 40 micron)	12	14
Grease plus 10% MoS_2 (Average particle size 0.5 micron)		
Range of best samples:		
Low	20	22
High	24	26

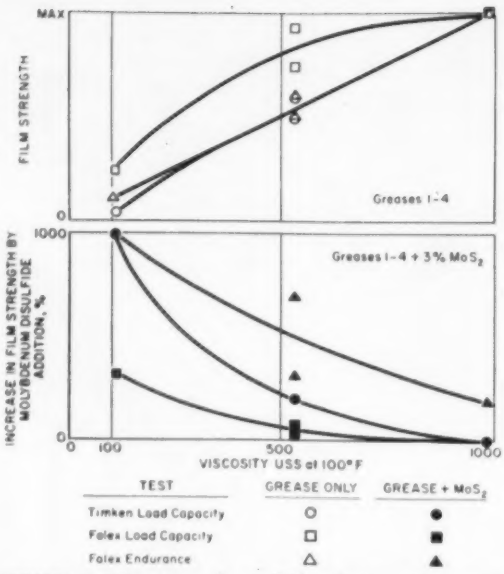

FIGURE 9. Film strength of lithium-base grease with and without MoS2 as affected by viscosity of contained oil.

TABLE IX

Summary of Lubrication Tests

Grease No.	*Type Grease*	*Soap Wt. %*	*Oil Viscosity SUS @ 100 F*	*Timken O.K. Load (lbs.)*	*Falex Load Capacity Transition Pressure, lb.*	*Timken Endurance (Minutes)*	*Falex Endurance (Minutes)*
1	Lithium	9.4	106	0.5	100	0	0.2
1	Lithium plus MoS_2			5	325	0	2.1
2	Lithium	11.0	537	5	300	0.7	0.9
2	Lithium plus MoS_2			10	425	24	2.9
3	Lithium	11.0	982	10	400	2	1.6
3	Lithium plus MoS_2			10	350	75	3.2
4	Lithium	5.0	537	6	375	0	1.0
4	Lithium plus MoS_2			12	500	530+	6.8
5	Sodium	10.0	537	6	500	13	2.0
5	Sodium plus MoS_2			12	450	75	1.4
6	Calcium	8.0	537	8	575	0	3.5
6	Calcium plus MoS_2			12	750	73	6.5
7	Aluminum	10.0	537	6	350	6	3.0
7	Aluminum plus MoS_2			6	450	6	1.0
8	Clay-Microgel	4.8	537	8	450	3	4.5
8	Clay-Microgel plus MoS_2			10	550	10	4.6
5212	Lithium	9.5	519	6	325	1.5	0.9
5212	Lithium plus MoS_2			8	450	43	1.7
5242	Clay-Microgel	4.8	537	10	450	30	4.0
5242	Clay-Microgel plus MoS_2			10	450	18	6.1
4A	Lithium			6	400	0	1.4
4A	Lithium plus MoS_2			10	450	3	6.0
4B	(E.P.) Lithium (M.P.)			16	500	450	8.5
4C	Lithium (M.P.)	5.0	80	8	400	8	1.0
4C	Lithium plus MoS_2 (M.P.)			16	425	76	9.4
4C**	Lithium plus MoS_2 (M.P.)			18	600	47	4.9

**Lot B-1799 Pulverized MoS_2 in this lube only.

Continued on page 30

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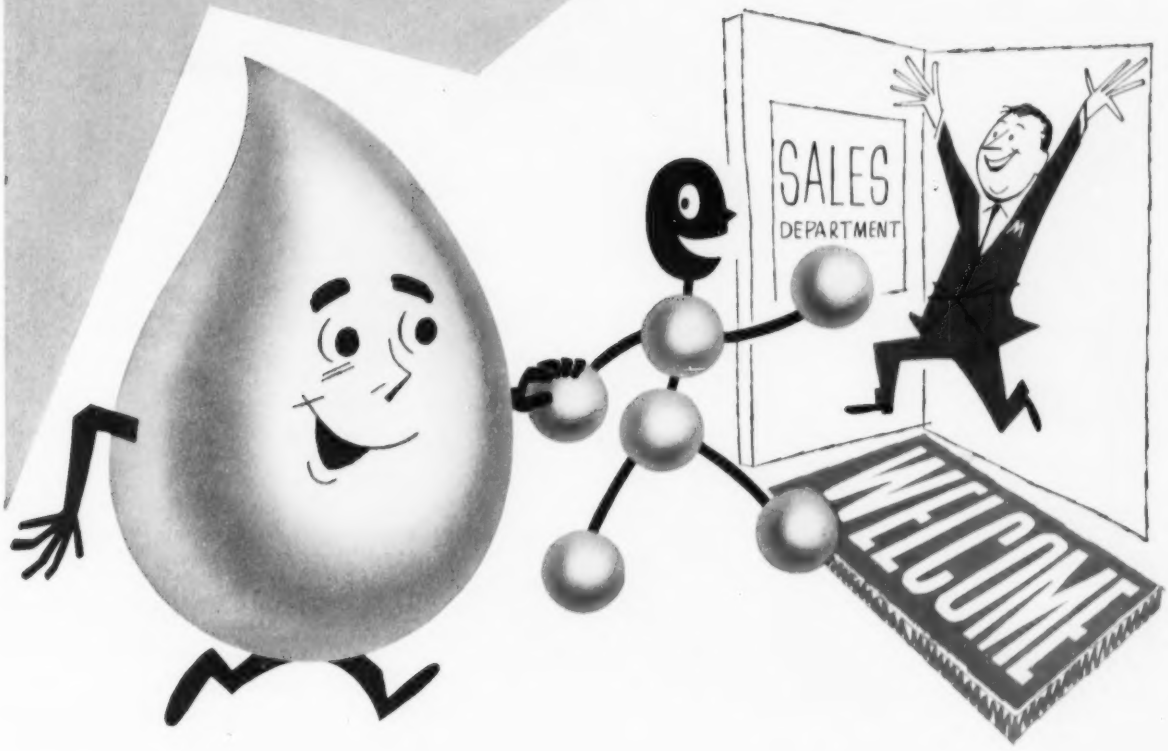

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You are all probably familiar with the oscillating friction machine described before this group and reported in the N.L.G.I. SPOKESMAN of July, 1954. This is a test for evaluating chassis grease in simulated shackle bolt service under wet and dry conditions. The results in Table XI, showing a virtual doubling of effective lubrication by the addition of 3% MoS_2 to a lithium-base grease, suggests the desirability of adding MoS_2 to chassis grease.

TABLE XI
Oscillating Friction Machine Test[5]
Lithium-Base Grease

Additive	*None*	*3% MoS_2*	*5% ZnO*	*15% ZnO*
Dry	350	564	336	555
Wet	162	264	109	85

Each figure is average hours to failure of two tests.

Another simulated service test may be run in the Kugelfischer grease testing machine. An indirect method is used to show the formation of MoS_2 films. This device for anti-friction bearing greases 4, 5, consists of two symmetrically arranged tapered roller bearings (30 206) rotated at a speed of 3,000 rpm.

In the tests, the results of which are shown in Figure 10, the pressure load, bearing temperature and test time are varied.[6] To determine film formation, changes in the friction of the test bearing is observed. Separate runs with the base grease are made before and after the runs with the MoS_2 grease under the same test conditions. In all cases, the same test bearings were used and thoroughly cleaned with organic solvents after each run. The solid curves are the results before testing the MoS_2 grease; the dotted curves, the values after testing with MoS_2 grease.

In Test 1, the MoS_2 grease was heated very rapidly under high pressure beyond its decomposition point (about 292F). The two comparative runs with grease, show a considerable difference in the shape of their curves. The frictional resistance differs by about one cm-kg and the temperature difference is about 41 F. The more favorable values are found after the MoS_2 grease has been tested. Accordingly, the MoS_2 must have filmed out of the *decomposed* grease onto the bearing surfaces.

In Test 2, the grease was heated only to 284 F, below its decomposition point. The pressure was the same as in Test 1. After the test, oil had visably separated, but the greater part of the grease still had its original consistency. The two test runs, before and after run with MoS_2 grease show an improvement in friction values in the second run. These results indicate that molybdenum disulfide forms a durable film on the bearing surfaces even *below* the decomposition temperature of the grease.

Tests 3 to 5 were run under lower loads to show the effects of pressure on film formation. In Test 3, the MoS_2 grease was heated rapidly above its decomposition point. After the test, it had collapsed with strong separation of oil. The two "before" and "after" test runs gave practically the same values. Thus the MoS_2 had not filmed out on the bearing despite the long duration of the test. Comparison with Test 1 shows that the effectiveness of MoS_2 depends not on the temperature or the collapse of the grease, but on the pressure.

In Test 4, carried out for two hours at 284 F, below the decomposition point, there was no change in the "before" and "after" test values. Similar results were obtained from Test 5, carried out at the same temperature but for a period of five hours. Apparently time is not a significant variable. In this test the MoS_2 grease had not collapsed, but did show a clear separation of the oil. Comparison of Tests 2 and 5 shows how the applied load influences performance of the MoS_2 grease.

In a further test with a load of 300 kg and temperatures 282 F to 302 F, the MoS_2 grease gave no lubrication difficulties during a run of five hours, although the grease was obviously tested in its decomposition range. A five-hour run on the test machine approximates the continuous use of a grease in actual practice. Since experience shows that an anti-friction grease without this additive would not have held up so long at its decomposition temperature, the MoS_2 may be assumed to have provided temporary emergency lubrication.

Field Service Results

Preliminary field service data on use of MoS_2 additive under practical conditions of use and test confirm the laboratory and simulated service test data reported here. The performance results suggest that in applications where mechanical motion periodically wipes, pumps, or shears away grease or oil films, the addition of MoS_2 to the grease can provide secondary lubrication protection. When the oil or grease film is temporarily removed, the film of MoS_2 on the metal bearing surfaces will sustain lubrication until the petroleum film is restored, either by release of the pressure forcing it away or by relubrication. Moreover, in marked

E. E. Smith

About the Author

Elwin E. Smith is Climax Molybdenum's manager of lubricant development. He is also the company's representative to NLGI. Smith has spent most of his business life in the petroleum industry developing markets for and selling lubricants as well as other petroleum products. Smith was previously with the Cities Service Oil company, beginning as sales engineer for general petroleum products, and progressing to sales manager for petroleum waxes and sales manager for industrial lubricants in the New York area. He joined Climax in 1955.

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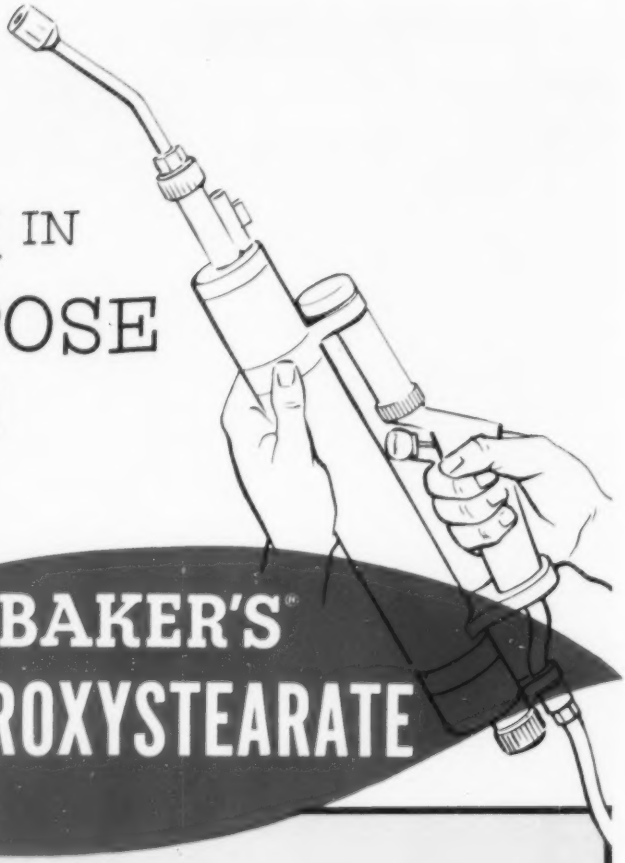

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contrast to sulfur and chlorine-containing additives which require high temperatures to chemically form ferrous sulfide or ferrous chloride films, MoS_2 does not require high temperatures to form low friction films on metal or other bearing surfaces.

Because of these unique characteristics, MoS_2 is being investigated by several major oil companies as an additive to chassis grease for automotive vehicles and to railroad grease for journals and bearings. It is also being added to tool joint compounds and, on a limited basis, to roll-neck greases. Results to date give promise that this use as an additive will solve a number of major problems in lubrication.

FALEX TESTS TO DETERMINE TRANSITION PRESSURE

Lubricant	*Transition Pressure, lb.*
Grease alone	500
Grease plus 10% MoS_2 (Average particle size 40 micron)	625
Grease plus 10% MoS_2 (Average particle size 0.5 micron)	
Low	1,000
High	1,250

NOTE: The Timken tests were made by hand blending 10% MoS_2 with a lithium base multipurpose grease. The test was conducted at room temperature with a single application of 4 grams of the mixture.

The Falex incremental loading tests were made at room temperature with a single 2.5 gram application of the mixed lubricant described above. The initial load was 500 lb. and it was increased in increments of 125 lb.

Acknowledgement

The author is also especially indebted to J. P. Binkelman, Dr. C. H. Kline and Messrs. E. K. Leavenworth, M. A. Sonntag, J. J. Craig, J. A. Bell and J. Mattie, for helpful discussions.

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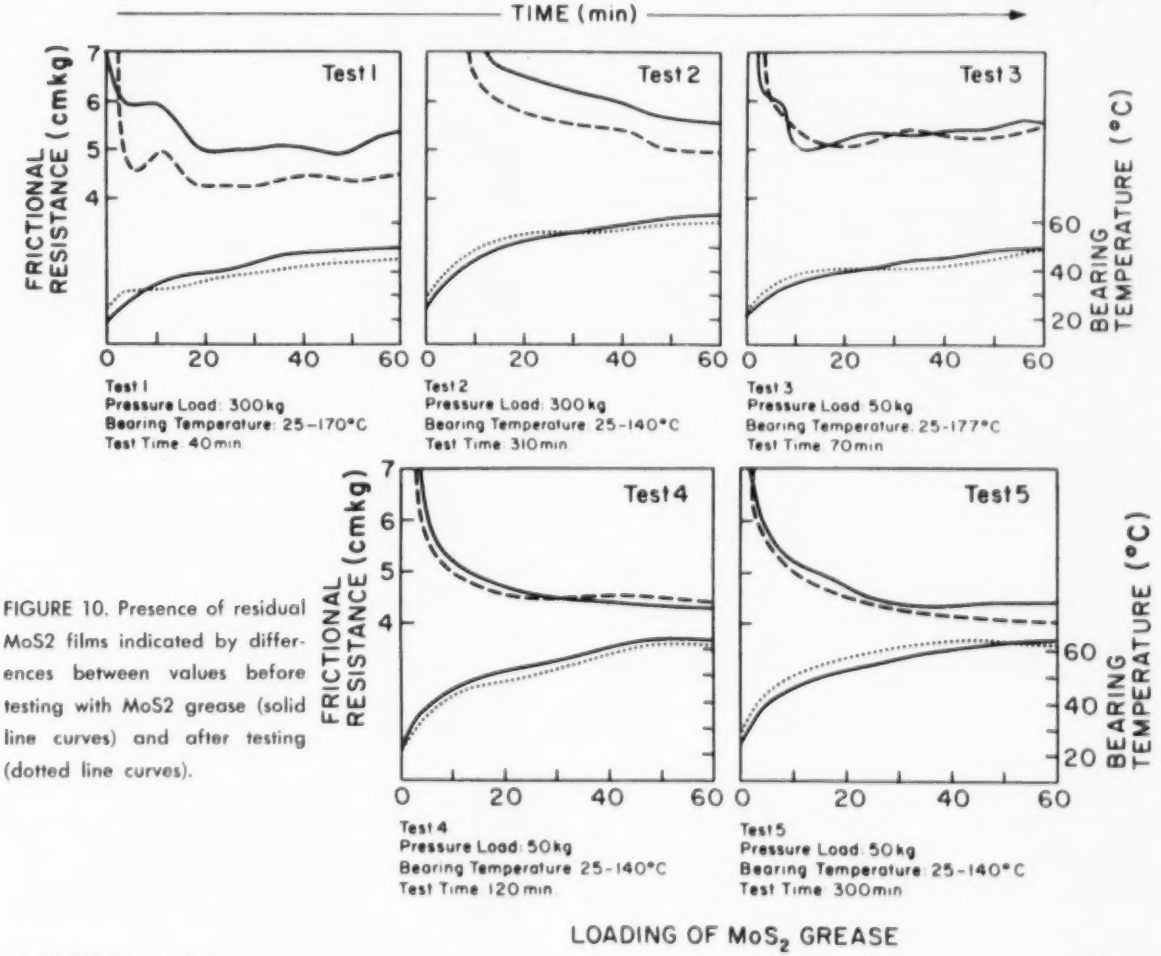

FIGURE 10. Presence of residual MoS2 films indicated by differences between values before testing with MoS2 grease (solid line curves) and after testing (dotted line curves).

Testing Machine of Professor G. Spengler," *Schmiertechnik*, 3, 19, (1956).
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APPENDIX A
Abrasion Test Procedure

The abrasion tester was built from a proposed design developed by ASTM Committee D-2 described in Reference 9.

1. *Preliminary Testing Procedure*

A. Clean the test bearing of preservative material by immersing and slushing in two washers of reagent grade benzene or naphtha, follow with two washes of USP grade ether. Transfer the bearing immediately to a vacuum desiccator and evacuate for fifteen minutes. Weigh the clean, dry bearing to the nearest 0.1 mg.

B. Place the bearing in the upper end of the bell so that the outer ring is seated firmly. Screw the bell tightly (by hand) on the cylindrical duct, thereby locking the bearing outer ring in place. Place the bushing on the shaft and finger screw the impeller tightly on the left hand thread located at the bottom of the shaft. The bushing serves to lock the inner ring of the bearing.

C. Place a 400 ml Griffin beaker around the bearing assembly with the bottom of the bell section of the duct ¼" above the bottom of the beaker.

D. Prepare a 30 gm ± 0.1 gm sample of test solid lubricant. Disperse the sample in 170 gm ± 0.1 gm of paraffin oil (Socony-Mobil Rubrex 100) by stirring with a spatula until scraping of the bottom of the beaker shows no aggregate of sample.

E. When uniform suspension of the sample has been achieved, the mixture is poured into the 400 ml beaker surrounding the bearing holder assembly until the level of the liquid is up to and covering one-half of the area of each porthold.

F. Turn on the motor and operate for 2 hr ± 5 min.

G. At the end of the test period, dismantle the apparatus. Slush the bearing in two washes of reagent grade benzene or naphtha, follow with two washes of USP grade ether. Dry the bearing in a vacuum disiccator for 15 min and weigh to the nearest 0.1 mg.

2. *Standard Testing Procedure Adopted for Molybdenum Disulfide Mixtures*

From the data accumulated in procedure studies, a standard testing procedure for molybdenum disulfide was established. This procedure is substantially the preliminary testing procedure described above, except for the following amendments:

A. To obtain an appreciable weight loss sensitive to an analytical balance, Item F in preliminary testing Procedure is amended to read 24 hr ± 5 min.

B. After the initial weight loss is determined (Item G of the preminiminary testing procedure), break the test bearing with a hammer and weigh the parts.

C. Washing the bearing parts by hand in laboratory calgonite and water, rinse in alcohol, ether, dry in a vacuum disiccator, and reweigh.

D. Add the initial weight loss and the loss of weight by detergent washing to give the total loss of weight for 24 hr.

E. Divide the total weight loss by 12 to give an average weight loss per 2 hr.

3. *Procedure for Coating Separate Test Plates by Suspending in Molybdenum Disulfide Mixtures*

A. Material–Annealed 1020 steel surface ground and vapor blasted with 100 mesh quartz grit to a surface roughness of 55 microinches, RMS.

B. Cleaning–
   1. Wash in water.
   2. Wash in 50-50 solution of acetone and benzene.
   3. Wash in methanol.
   4. Dry and store in disiccator until used.

C. Weigh.

D. Suspend in slurry around the bearing and operate apparatus for 2 hr.

E. Reweigh and calculate weight of film formed.

APPENDIX B
Procedure for Preparation of Specimens for Analysis by X-ray Diffraction

The presence of molybdenum disulfide may be detected by measuring the intensity of the radiation reflected by the (0 0 2) planes of the crystals of molybdenum disulfide. Although it is possible to cut samples from the bearings and examine them directly, the procedure is time consuming. For quantitative work the crystals of the sample should have a random orientation, but most films of molybdenum disulfide are highly oriented. Both of these difficulties were avoided by rubbing the bearing surfaces with one-inch squares of 3/0 emery paper to remove some of the surface material. These squares together with an unused square and a square which has been rubbed against molybdenum disulfide film of known weight are examined in an X-ray diffraction apparatus.

APPENDIX C
Method of Test for Evaluating Anti-Wear Characteristics of Turbine, Motor and Gear Lubricating Oils ((Falex Wear Test))

The Falex tester is a drill press-type device for rotating a ¼" diameter pin within a V-shaped bearing formed in two ½" long blocks. The blocks or test specimens with the V-grooves are placed in vertical position in self aligning recesses in the lever arms or jaws of the load applying mechanism (same principle as nut cracker). This mechanism is loaded hydraulically at the ends of the lever arms opposite the specimens. The test cup holding sample is placed in posi-

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tion so that the lines of contact of the V-grooved blocks and rotating pin are submerged in the sample.

A. The key operating conditions for the 2-hour wear Test (USN Procedure) are as follows:

Pin r.p.m.	290
Sample Temperature F.	250
Jaw Load, lbs. (Max.)	200
applied in 50 lb increments of 3 min. duration	
Sample Charge, cc.	55
Test Specimen Material	Steel (V blocks & pin)
Duration of Run hrs.	2

The jaw load and temperature are checked at 15 minute intervals. The total weight loss (mg) of the test specimens (blocks and pin) is reported at test completion.

APPENDIX D

The Timken Endurance Test

This test procedure is being used for the determination of film permanence by means of the Timken wear and lubricant tester in the study of greases and additives.

PROCEDURE

Lubricant:

Fifty milligrams of the lubricant to be tested is placed evenly on the bearing surface of the test cup.

Load:

The machine is started, and after a 30-second break-in period a 10-pound load is applied at the rate of 20 pounds per minute with an automatic loading device.

Speed:

800 rpm or 400 surface feet per minute.

Termination:

Destruction of the bearing surface. The endurance time is recorded.

Bearings:

Standard test cups and blocks furnished by the Timken Roller Bearing Company.

Cleaning:

A new test cup and block surface is used in each test after washing in mineral spirits and drying.

APPENDIX E

Falex Incremental Load and Transition Pressure Test

The Falex incremental load test has been revised for a means of determining load capacity of greases and additives by detection of the transition pressure.

PROCEDURE

Lubricant:

Six milligrams of the lubricant to be tested is placed evenly on the bearing area of the test pin.

Load:

The machine is started and a 100-pound load is applied by the ratchet arm; time, temperature and torque are recorded. After one minute, the second increment of load is added in the same manner and readings are taken. The test is continued by increasing the load by 100-pound increments each minute to seizure, and the transition pressure prior to seizure is recorded.

Termination:

Failure of film may first be detected by small increases in torque, during the transition pressure period, which will be followed by pronounced increase in torque and temperature and weld seizure.

Bearings:

Standard pins and "V" blocks supplied by the Faville LeVally corporation.

Cleaning:

A new pin and new blocks are washed in mineral spirits and dried prior to each test.

APPENDIX F

The Falex Endurance Test

This test procedure is being used for the determination of film performance by means of the Falex lubricant tester in the study of greases and additives.

PROCEDURE

Lubricant:

Six milligrams of the lubricant to be tested is placed evenly on the bearing area of the test pin.

Load:

The machine is started and a 350-pound load is applied with the ratchet arm.

Speed:

290 rpm or 19 surface feet per minute.

Termination:

Seizure or definite increase in temperature and torque, the film endurance time is recorded.

Pins and Blocks:

Standard parts supplied by the Faville LeVally corporation.

Cleaning:

The pins and blocks are washed in mineral spirits and dried prior to each test.

APPENDIX G

The Fifty Milligram Load Capacity Test

This test was adopted as a means of evaluating the film strength of greases and additives on the Timken wear and lubricant tester.

PROCEDURE

Lubricant:

Fifty milligrams of the lubricant to be tested is distributed evenly over the bearing area of a new test cup and block surface for each test.

Load:

The loads are applied for a ten-minute period as in the Timken recommendation for the load capacity test, and the "Score" and "OK" scar loads are recorded.

Loading Rate:

After a 30-minute break-in period the load is applied at the rate of 20 pounds per minute with an automatic loading device.

Speed:

800 rpm or 400 surface feet per minute.

Cleaning:

The standard Timken test cup and block are washed in mineral spirits and dried prior to each test. ■

Patents and Developments

Complex Ester Base Lubricating Grease Compositions

It is known in the lubricating art that the dispersing agent most desirable for a grease formulation is the lubricating oil which would be selected for the lubricating application if a lubricating oil could be used. That is to say, when the application of the lubricant calls for a lubricating grease composition, the best grease is one which is made from a lubricating oil which would furnish the best lubrication if a liquid could be used. This premise is basic in the art of lubricating grease manufacture.

In lubrication applications that call for an outstanding lubricant particularly in respect to wide temperature ranges, it has been found that synthetic lubricants are generally more satisfactory than mineral base lubricants. This is particularly true in the lubrication of moving parts of jet engines used in aircraft, either the "turbo-jet" engine or the "turbo-prop." Extremely varied temperature range is experienced by these engines and it has been found in the past that mineral oil base lubricants are generally unsatisfactory. Accordingly, the lubricating art has developed a line of synthetic lubricants for these applications.

Some of the most popular of these synthetic lubricants are those of the ester type. Synthetic lubricating oils which comprise esters of dibasic acids and complex esters formed from mixtures of alcohols, dibasic acids and glycols have been found to be of outstanding importance in meeting the stringent conditions imposed upon lubricants by this modern technology.

One of the major problems in the manufacture of the complex ester synthetic lubricant has been the high residual acidity of the final product. This is harmful in that the corrosivity to contacting metal parts at high temperatures causes a rapid deterioration of the bearing surfaces. Therefore the application of these otherwise excellent complex ester type synthetic oils has been curtailed.

In accordance with U.S. Patent 2,751,351 issued to Esso Research and Engineering Company, a complex ester type synthetic oil having outstanding low temperature properties may be prepared by the interaction of 2 molecular proportions of a branched chain alcohol having from 6 to 16 carbon atoms, such as branched hexanols, heptanols, octanols, 6 methyl-1-heptanol, 2 n-propyl-1-pentanol, 3 n-propyl-1-pentanol, 2, 2-dimethyl-1-octanal, 4, 5-dimethyl hexanol,

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3, 5-dimethyl hexanol, di-2-ethylhexanol, C_8 Oxo alcohol, C_9 Oxo alcohol, C_{13} Oxo alcohol, etc., with 2 molecular proportions of a dibasic acid, such as adipic, azelaic, sebacic or glutaric acid, and with 1 molecular proportion of a 1, 3-glycol. The preparation of one such synthetic lubricating oil is set out in detail as follows:

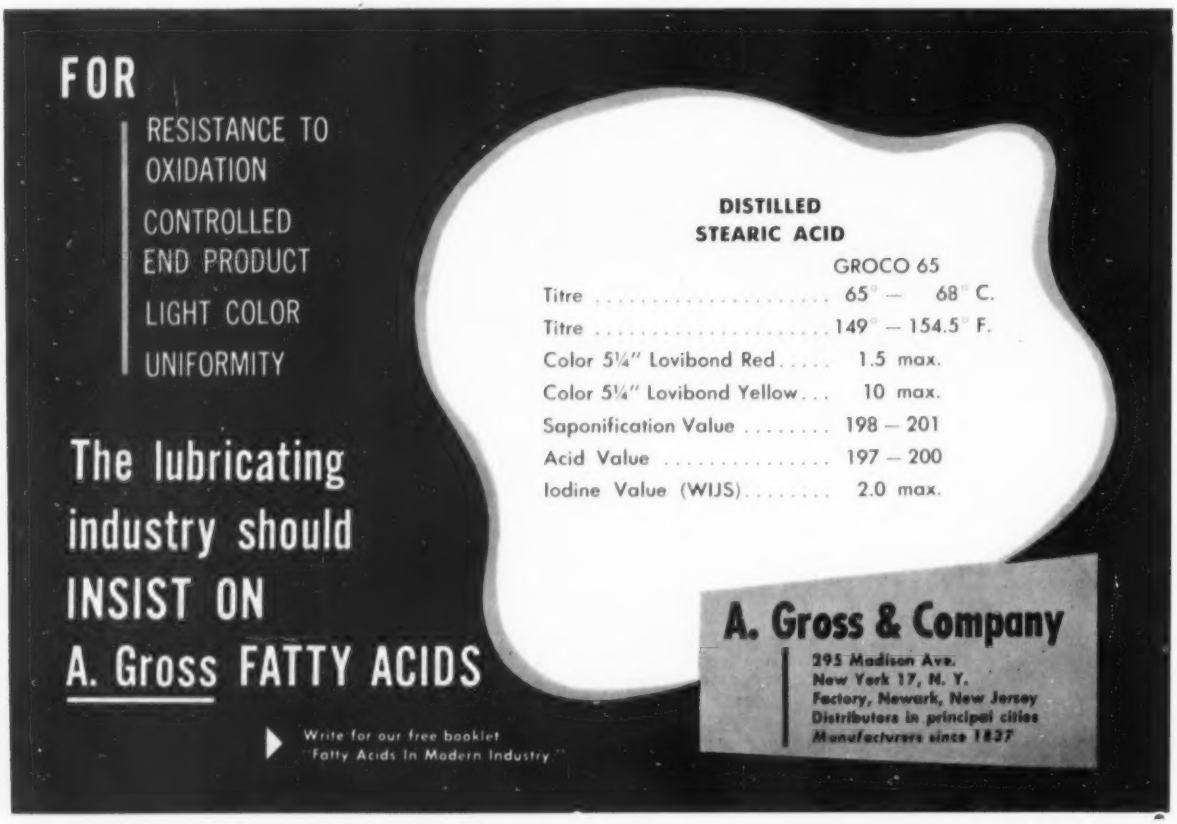
180 grams (2 mols) of a glycol, e.g. butane diol 1, 3, 520 grams (4 mols) of a branched chain alcohol having 8 carbon atoms e.g.C_8 Oxo or isooctyl alcohol, 584 grams (4 mols) of adipic acid, 6, 4 grams of 2.6 di-t-butyl-4-methyl phenol and 200 grams of xylene were paced in a 2 liter 3-neck flask fitted with a water cooled condenser and a side arm takeoff tube, used to remove the water of reaction. The mixture was heated at the boiling point for 16 hours and at this point 138 ml. of water as a by-product was removed. However, the ester has an acid number equal to 66.8 ml. KOH (0.1 N) per 5 ml. of sample. To help reduce the acidity 45 grams more of 1, 3-butane diol was added and the mixture heated for 16 hours at the boiling point. At this point the acidity was 10.3 ml. of KOH (0.1 N) per 5 ml. of sample. As this acid number was still quite high there was added 22.5 grams more of 1,3-butane diol and 65.0 grams of isooctyl alcohol. Upon heating to the boiling point for 16 more hours the acidity was reduced to 0.5 ml. of KOH (0.1 N) per 5 ml. sample. The sample at this point was heated under 3mm. Hg vacuum to a pot-temperature of 200°C. and an overhead temperature of 143°C. The total weight of final ester as bottoms after stripping was 1313 grams and the by-product overhead was 254 grams.

This complex ester had the following ASTM inspections:

Pour Point (°F.)	−75
Viscosity at 210°F. (cs.)	5.35
Viscosity at 100°F. (cs.)	26.15
Viscosity at −40°F. (cs.)	9997.0
Flash point (°F.)	440
Acid No. (ml.) KOH/5 g. sample	.5

This ester has excellent low temperature properties as evidenced by the viscosity at −40°F. It also has outstanding viscosity-temperature relationship as is shown by the viscosity of 100°F. and 210°F. Its flash point is sufficiently high so as to make it applicable for lubrication at extremely high temperatures. However it will be noted that the acid number of the ester indicates that its residual acidity makes it undesirable for lubricating use in some applications.

As was stated above, the use of this synthetic ester lubricant as a dispersing agent for grease compositions would be desirable in applications where its low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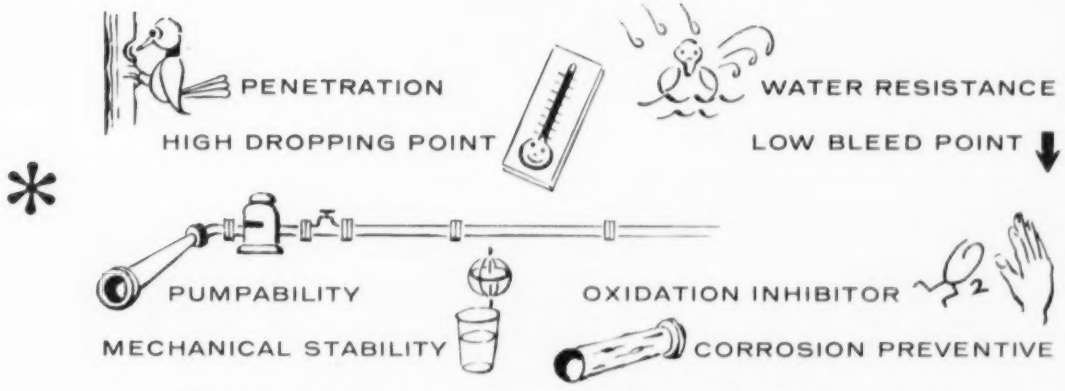

* The action of lithium as a gelling agent dominantly controls the first four of these functional properties. Fatty acids, oil and auxiliary additives influence the last four. Lithium does not adversely affect any of these critical properties.

There are definite manufacturing and marketing advantages in producing lithium-based grease. Inventory control is but one of them. Being a true multipurpose product, only one lithium soap grease is needed to lubricate your car: chassis, water pump, wheel bearings and universal joints. Often, several single-purpose lubricants are replaced in special industrial applications. Of equal significance is Lithium Corporation's acceptance in the field: over 10 years' production experience supplying lithium hydroxide to the grease industry. Add to this our unsurpassed production facilities and you are assured of a reliable source of consistently uniform quality LiOH, available from inventory for immediate shipment. Since we are equally interested in developing better lithium products, why not get in touch with us? A card or letter will bring immediate response.

. . . trends ahead in industrial applications for lithium

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PROCESSORS OF LITHIUM METAL • METAL DERIVATIVES: Amide • Hydride SALTS: Bromide • Carbonate • Chloride • Hydroxide • SPECIAL COMPOUNDS: Aluminate • Borate • Borosilicate • Cobalite • Manganite • Molybdate • Silicate Titanate • Zirconate • Zirconium Silicate

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temperature and good viscosity-temperature relationships could be utilized. However, its high residual acidity again would militate against its choice. It has now been found that a grease composition using this complex ester may be prepared by a process whereby its residual acidity is removed. The resulting grease composition contains no harmful residual acidity and retains all the desirable properties of the complex ester.

It has been found in the lubricating grease art that attempts to prepare a lubricating grease utilizing a synthetic oil by ordinary grease forming techniques are unsuccessful. This is due to the fact when common soap forming acids are utilized with a metal base such as metallic hydroxide, hydrolyzation of the ester occurs and the resulting product is a mixture of soap and the various components of the ester. According to the patent, however, the soap thickener is prepared in a mineral lubricating oil in such a manner than an excess of the metallic hydroxide is present. This excess metallic hydroxide then neutralizes the residual acidity of the complex ester and the resulting grease formulation is a smooth consistent product that is either neutral or slightly alkaline depending upon the amounts of metallic hydroxide in excess. An illustration of the technique of the formulation of the lubricating greases of this patent is as follows:

Formulation	Per Cent
Hydrogenated fish oil acid	15
Lithium hydroxide monohydrate	2.20
Phenothiazine	0.5
Mineral oil (35 SUS at 210°F.)	20
Complex ester described above	62.3

Procedure

The hydrogenated substantially saturated fish oil acids (Hydrofol 54) and the mineral oil were charged to a fire heated grease kettle equipped with efficient means of agitation and heated to 150°F. The lithium hydroxide monohydrate was then charged at a hot 15% aqueous solution. Heating was continued to 250°-300°F. where the soap was completely dry. The complex ester was then added and the temperature raised to 420°F. The phenothiazine was added and the fluid material drawn into pans in thin layers where it was rapidly cooled. The cold cakes of grease were then returned to a cold kettle, worked to a homogeneous mass, and milled or homogenized to a uniform product.

Resulting grease composition had the following ASTM inspections:

Penetration (mm./10, 77°F.):	
Unworked	295
Worked (60 strokes)	320

Continued on page 44

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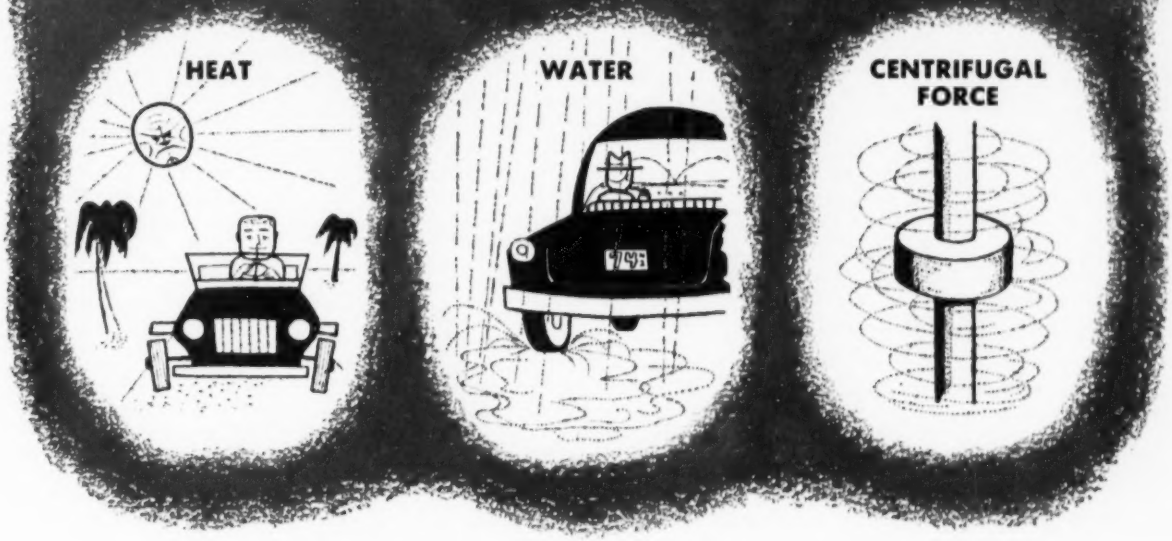

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Auburn, Indiana
Representative—Mahlon E. Rieke

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Representative—Walter N. Callahan

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Cleveland 2, Ohio
Representative—Frank C. Haas

Armour & Co., Chemical Division
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Representative—W. L. Riegler

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Representative—R. F. Brown

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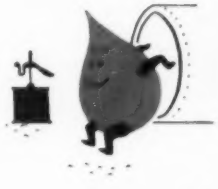

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BAROID DIVISION
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BENTONE* 34
FOR MULTI-PURPOSE GREASE

5631

Water solubility ..... Insoluble in boiling water
Per cent free alkalinity ..... 0.05 (as LiOH)

This grease formulation was submitted to NLGI-ABEC spindle life test which is described in detail in the December 1949 addition to "Lubrication," vol. 35, N. 12, a technical publication devoted to the selection and use of lubricants, published by the Texas Oil Company. Operating at 250°F. at 10,000 R.P.M. this grease gave a spindle life of 1400 hours.

In the standard Norman-Hoffman oxidation bomb test, the grease of Example I gave the following results, indicating excellent resistance to oxidation:

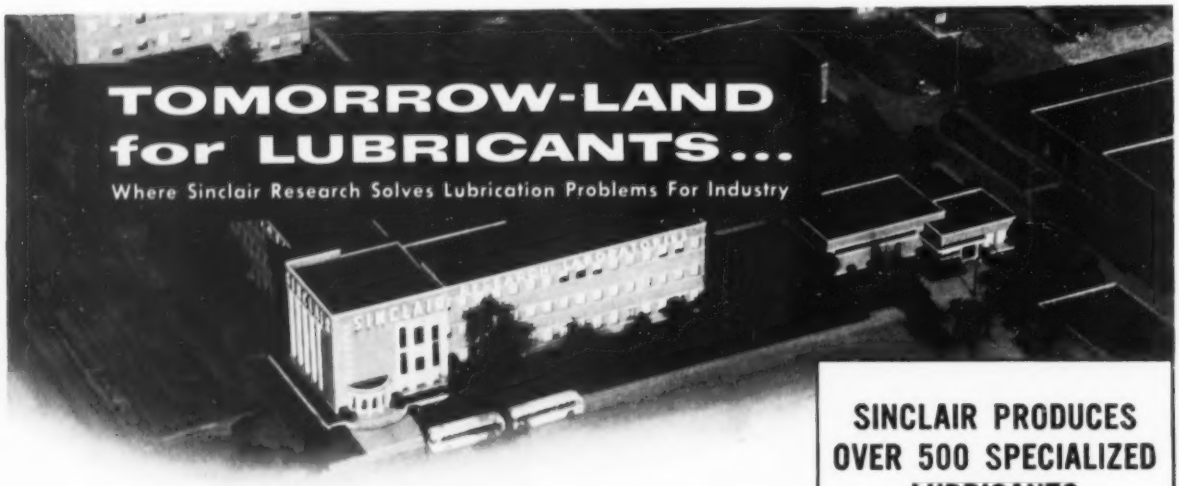
Hours	*P.s.i. drop in pounds' pressure*
55	2
163	4
250	12
450	24
500	31

Basic Aluminum Alkanoate Gelling Agents

A basic aluminum alkaloate, more applicable as a thickener for incendiary bombs use, is outlined in U.S. Patent 2,751,359 issued to Standard Oil Company (Indiana). A presolvated aluminum soap gelling agent, for the same purpose, is also covered by the same company in its U.S. Patents 2,751,360 and 2,751,361.

Wear Test Method

According to U.S. Patent 2,751,506, issued to Esso Research and Engineering Company, a wear test is disclosed wherein two iron-containing metallic objects are first irradiated by bombardment with neutrons to produce radioactive Fe^{55} and Fe^{59} isotopes in the iron-containing metallic objects. This irradiation of the two metallic objects is carried out at different times so that the radioactivity in one of the objects is allowed to decay prior to the wear test. In accordance with the patent therefore, the metallic object which is first irradiated is aged to substantially eliminate the Fe^{59} isotope which has a relatively short half life so that the radioactivity of the aged metallic object is primarily due to the radiation from the Fe^{55} isotope. The two metallic objects are then subjected to a wear test in which they are mutually lubricated by a common lubricant. The lubricant is then analyzed by separately measuring the gamma radiation due to the Fe^{59} isotope in the lubricant with a thick-walled radiation counter and then separately measuring the X-radiation due to the Fe^{55} isotope and the beta radiation due to the Fe^{59} isotope in the lubricant with a thin window or windowless radiation counter to therefrom determine the amount of wear of each of the two metallic objects.



Located at Harvey, Illinois, is one of the most extensive installations of its kind in the world—Sinclair Research Laboratories. These facilities are an important part of Sinclair's investment in the future. Here is where Sinclair engineers and chemists work to develop new products and improve the quality of existing ones. At these famous laboratories were developed the Sinclair lubricants now solving difficult problems in all branches of industry. If you have a special lubrication problem, write today to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y.

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and many other applications

SINCLAIR REFINING COMPANY

PEOPLE in the Industry

Du Pont Appoints C. W. Ferris

Carl W. Ferris has been named manager of the newly created Chicago district of the central region of Du Pont's petroleum chemicals division, it was announced by David H. Conklin, director of sales of the division.

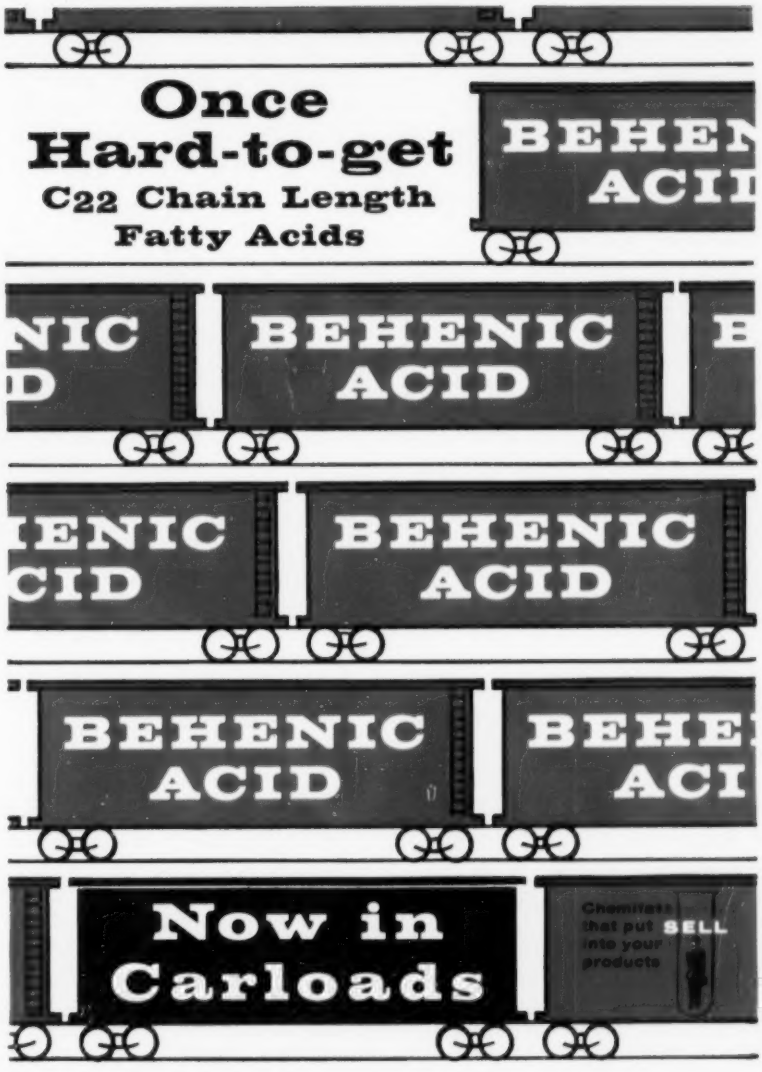
The new district, second to be formed in the central region this year, will provide greater service to the oil industry in the Chicago area and will consist of Illinois, Indiana, Missouri and parts of Michigan, Iowa, Kentucky, Tennessee and Wisconsin. The Cleveland district was the first such subdivision to be formed in the central region.

A mechanical engineering graduate of Cornell, the new district manager joined Du Pont in 1947. He did test work, investigating exhaust valve burning, spark plug fouling and power losses at the company's petroleum laboratory at Deepwater Point, N. J. He was assigned to the central region in 1951 and has been an account manager working out of the Chicago regional office.

H. W. Schultze Joins Climax Molybdenum

Dr. H. W. Schultze has joined Climax Molybdenum company as assistant manager of chemical development, it has been announced by R. E. Warriner, vice-president—sales.

In his new position, Dr. Schultze



This highly pure, saturated, long-chain acid, now available in production quantities, will help you develop interesting new products.

ADM Behenic Acid can be esterified with fatty alcohols to produce high melting point waxes. Because it stabilizes emulsions this material is ideal for soaps, lotions, cosmetics, lubricants, chemical intermediates, esters, stabilizers, and specialties.

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Hydrogenated and Distilled Fatty Acids and Stearic Acid . . . Hydrogenated Vegetable, Fish, Sperm Oil and Tallow . . . Hydrogenated Castor Oil . . . Stearyl, Cetyl, Oleyl Alcohol . . . Sperm Oils and Spermaceti . . . Behenic Acid . . . Erucic Acid . . . Hydroxystearic Acid . . . Olefins . . . Hydrocarbons.

AVERAGE SPECIFICATIONS	
Titre	69 to 73°C
Acid Number	168 to 174
Iodine Number	4 (Max.)
Saponification Number	169 to 175
Average Molecular Weight	320 to 332
Specific Gravity @ 100/25°C	0.8286
Color (5¼" Lovibond)	Max. 25 Y/2.5R

Archer-Daniels-Midland company
CHEMICAL PRODUCTS DIVISION
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will be responsible for expanding the use of molybdenum catalysts in the process industries and for the development of new chemical applications of molybdenum compounds.

Prior to joining Climax, he was in the product and process development department of the Electro Metallurgical company, a division of Union Carbide and Carbon corporation.

Dr. Schultze received an A.B. degree in science from New York State Teachers college at Albany and his Ph. D. in chemistry from Rensselaer Polytechnic Institute, where he was a member of the teaching staff from 1951 to 1955. His doctoral thesis at R.P.I. was a study of metal chelates. He has published work, sponsored by the A.E.C., in the field of radio-active fallout.

Professional affiliations include the American Chemical Society, the American Institute of Mining and Metallurgical Engineers and the American Society for Metals. He served in the U. S. Navy in 1945 and 1946.

Emery Appoints A. C. Fusaro

The appointment of A. C. Fusaro to the position of assistant director of advertising is announced by L. E. Francis, director of advertising of Emery Industries, Inc., Cincinnati, Ohio. Mr. Fusaro joined Emery in 1947 as a member of its technical staff. He has been associated with the advertising department since 1950, where he has handled the advertising for Emery's Chemical Division. In his new position he will assist in the supervision of all Emery advertising at the local and national levels.

Mr. Fusaro is a graduate of the Chemical Engineering Department of the University of Cincinnati, and also holds a Certificate in Advanced Management from that school. He is a member of the Advertisers Club of Cincinnati and the Association of National Advertisers.

Stahl and Knippling to Research

The appointment of Albert F. Stahl and Robert Knippling to the process research section of Emery Industries, Inc., Cincinnati, Ohio, was announced by Dr. R. G. Kadesch, director of research. They will be associated with the production group under the direction of Dr. K. T. Zilch, where they will conduct research on both new and existing methods for producing fatty acids and their derivatives.

Stahl obtained his B. S. degree in chemical engineering from the University of Cincinnati and is a member of the American Institute of Chemical Engineers. Prior to joining Emery he was a project engineer with Becco chemical division of Food Machinery and Chemical corporation.

Mr. Knippling is a graduate of Wilmington College, Wilmington, Ohio. For the past four years he has served in Emery's control laboratory. He is affiliated with the American Oil Chemists' Society.

American Potash Announces Promotions

American Potash & Chemical corporation has announced two promotions in the research department of the company's main plant at Trona, Calif.

Dr. Donald Garrett has been named as assistant manager of the Trona research department, while Stanley Cohen has been appointed

HARSHAW LEAD BASE

Harshaw Lead Base, as an additive to petroleum lubricants, improves extreme pressure characteristics and imparts the following desirable properties:

- Increased film strength
- Increased lubricity
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- A strong bond between lubricant and metal surfaces
- Resistance to welding of metals at high temperatures
- Moisture resistance and inhibits corrosion

Harshaw Lead Bases are offered in three concentrations to suit your particular needs:

Liquid	Liquid	Solid
30% Pb	33% Pb	36% Pb

Other metallic soaps made to your specifications. Our Technical Staffs are available to help you adapt these products to your specific needs.

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almost
Everything that moves
DEPENDS ON GREASE!

Almost everything that moves either in actual operation or in the process of its making . . . from gate hinges to tractor wheels . . . depends upon grease. That is why lubricants should be bought with care. You can always depend upon Deep Rock highest quality greases and lubricants. They are manufactured to give top lubrication to all moving parts.

DEEP ROCK
DEEP ROCK DIVISION
KERR-McGEE OIL INDUSTRIES, INC.
306 N. ROBINSON · OKLAHOMA CITY
PHONE RE 9-0611

head of the new products section.

Garrett succeeds Harold Mazza who recently was appointed manager of research at AP&CC's Los Angeles plant.

Joseph Adinoff has been promoted to senior development engineer of American Potash & Chemical corporation, according to an announcement by H. B. H. Cooper, director of development engineering for the company.

Adinoff previously was chief engineer at AP&CC's Los Angeles plant. Under the new assignment he will headquarter at the company's main office, also at Los Angeles.

Charles Field has joined American Potash & Chemical corporation as formulations chemist at the company's Los Angeles plant. Field previously was with National Carbon company's Eveready Battery plant at Cleveland, Ohio.

Field was graduated with a B. S. degree from Iowa State College at Ames, Iowa, in 1952.

Socony Mobil Announces Promotions of Judah and White

P. W. Judah, manager of the lubricating department of Socony Mobil Oil Company, Inc., since 1952, has been appointed manager of a newly-established petroleum chemicals department.

In addition to acting as a clearing house for activities in the petroleum chemical field in which the company already engages, the new department will be responsible for the sale of the company's chemical products, and will initiate market research studies, recommend laboratory research programs and make continuing evaluation of opportunities in manufacturing and marketing related to petroleum chemicals.

Mr. Judah, who was graduated in engineering from Purdue University in 1928, joined Socony Mobil as a service station attendant at Elmira, N. Y., in 1932. He was a junior industrial salesman in Buffalo in 1934 and became industrial district manager in Boston in 1945. He was transferred to the company's headquarters in 1949, as manager of the industrial division of the lubricating department. He became manager of that department on Jan. 1, 1952.

Paul A. White, who has been associated with the company since 1937, has been appointed manager of the lubricating department, succeeding P. W. Judah, according to Vern A. Bellman, general manager of domestic marketing.

Mr. White started his career with Socony Mobil as an industrial sales engineer. In 1943 he was promoted to sales supervisor. Then followed promotions to chief engineer of the Wadhams division at Milwaukee and to division industrial manager. In 1955 he was appointed manager of the engine builders division in the lubricating department at the headquarters office in New York.

He was born in Sigourney, Iowa, near Des Moines and attended high school at Wellington, Kans. He was graduated from the University of Kansas with a B. S. degree in 1930.

Cooperative GLF Appoints Wolf

Petroleum Division of Cooperative GLF Exchange, Inc., has appointed Raymond J. Wolf to head up special sales of petroleum products outside the GLF system.

In announcing the appointment, division manager Ronald B. Fitch said the move follows a decision of the farm cooperative's board of directors, to make sales outside GLF when such business contributes to the use of efficiency of GLF facilities and manpower.

Before the appointment, the GLF wholesale division sold only to GLF retail agencies.

H. Ellis Ross, division personnel supervisor, replaces Wolf as sales-service supervisor for the division's 66 bulk plants in New York, New Jersey and Pennsylvania.

Chek-Chart's Shaw Appoints Balfour

Raymond Shaw, president of The Chek-Chart corporation, has announced the appointment of Robert L. Balfour as assistant to the president.

Balfour, 38, brings to Chek-Chart a wide background in sales, public relations and advertising. In the past, he has been engaged as a consultant to the Foreign Operations Administrator in Washington, D. C.

Prior to joining the Chek-Chart corporation, Balfour, a graduate of the University of Missouri journalism school, also served as sales and marketing manager for Shopmaster, Inc., a subsidiary of the Jones & Lawson Machine corporation.

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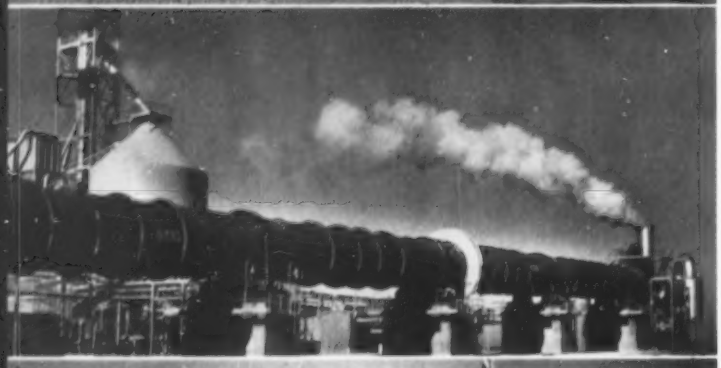

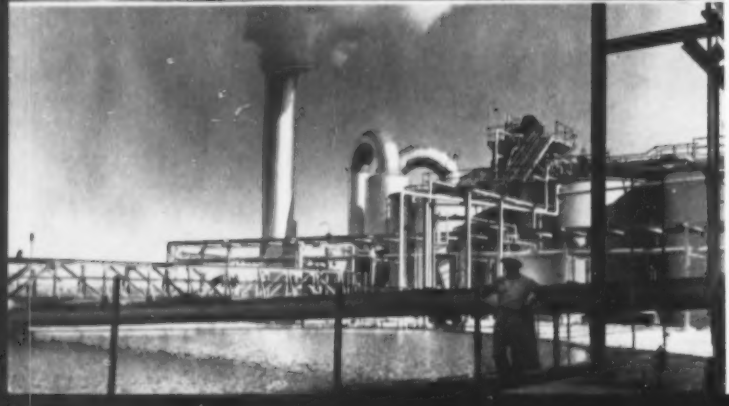

NEW
MEMBER

American Potash and Chemical Corporation Joins NLGI

1. Aerial view of Trona, Calif. shows main plant.
2. Gigantic kiln, used to roast lepidolite lithium ore and limestone at San Antonio, Texas.
3. Main office of American Potash at Los Angeles.
4. Huge stacks of lepidolite lithium ore are refined to make lithium hydroxide. Supplied from Africa.
5. Kiln feed tanks, gas scrubbers, San Antonio.

ONE OF THE LARGEST producers of lithium chemicals is American Potash & Chemical Corporation, which manufactures lithium carbonate at its main plant at Trona, Calif., and lithium hydroxide at its subsidiary, American Lithium Chemicals, Inc., located near San Antonio, Texas.

The carbonate is used primarily for porcelain enamel coatings and ceramic glazes, while the hydroxide plays an important role in the petroleum industry in all-purpose greases.

These greases, which function with equal efficiency in the Arctic regions or tropic climates, were developed during World War II for our armed forces. More recently, they have been finding growing use among grease manufacturers for civilian vehicles, and it is believed that most automotive greases will contain lithium within a few years.

American Potash & Chemical Corporation, which produces more than 60 chemicals for industry and agriculture, entered the lithium field in 1938 when it began producing crude lithium concentrates at its Trona plant, located approximately 175 miles northeast of company headquarters at Los Angeles. Since 1951 these concentrates have been upgraded to lithium carbonate for use by industry.

Because of increasing demand for lithium compounds, AP&CC began a sizable expansion of its lithium chemicals production as part of the company's long-range development program.

In November of 1953, AP&CC completed negotiations with Selection Trust Ltd. and The American Metal Company, Ltd., to develop a lithium deposit located at Bikita, Southern Rhodesia, Africa. The Bikita deposit is believed to be the world's largest high-grade deposit of lithium-bearing lepidolite.

During 1954 the company formed American Lithium Chemicals, Inc., for which a $6,100,000 plant was completed at San Antonio in December of 1955 to produce lithium hydroxide.

With completion of the plant, lithium became a major product of American Potash & Chemical Corporation, along with potash, soda ash, salt cake and borax.

The company, with its main office at Los Angeles, is one which has grown with the West and has become an aggressive part of the chemical industry.

Of the company's products, more than 20 chemicals are extracted by an extremely complicated process at the Trona plant from brine pumped from beneath nearby Searles Lake, a huge dry lake-bed of 30 square miles. It is believed the lake was formed thousands of years ago by glacial streams originating in the High Sierra.

Among the long list of chemicals the company manufactures for agriculture and industry, the most important are potash, borax, soda ash, salt cake and lithium. It is the largest potash producer on the Pacific Coast and the second largest borax manufacturer in the world. It is the second largest producer of soda ash in the western United States, and produces more salt cake than any other manufacturer in the world. The firm is one of the major manufacturers of lithium chemicals in the world.

The company's potash production is used in chemical fertilizers, soaps, textiles, matches, medicines, dyes, glass, photographic preparations, pigments, synthetic rubber and many other products.

Although American Potash & Chemical Corporation's main market is in the western United States, the company ships its products all over the world. Greatest international demand is for borax because approximately 95 per cent of the world's supply is concentrated in Southern California. Borax affects the everyday lives of almost the entire world's population because of its use in a multitude of so-called "finished" products. Glassware, cooking utensils, lightbulbs and even television tubes; enamels on kitchenware and glazes on dinnerware; clothing and leather goods; chemical fertilizers, weed-killers and defoliants and ever preservatives to keep the freshness of oranges; medicines and cosmetics, soaps and detergents, antifreeze, fireproofing materials – all these and many more involve the use of borax.

The main use of soda ash is in the manufacture of glass, but substantial quantities also are employed in mining and metallurgical processes, soaps, detergents, drugs, dyestuffs, water softener agents, refining of lubricating oils and others.

Salt cake, principally utilized in the manufacture of kraft paper, also is employed in the production of plate and window glass, synthetic detergents, textile and leather processing, pharmaceuticals, stock feeds, metallurgical processes, to name some.

The company's fifth major product is lithium, used in porcelain enamel because of its ability to make enamels flow easily, in all-purpose greases which act with equal efficiency in sub-zero or tropical temperatures, in air-conditioning because of its de-humidifying properties, in alkaline batteries for submarines, and in other articles vital to our industrial well-being.

These are only a few of American Potash & Chemical Corporation's products and a few of their uses. There are many more products and many more uses, nearly all having an effect on Americans every day of their lives. ■

Industry NEWS

Southwest Grease and Oil Looks to the Future

Construction schedules, aimed at a January 1, 1957, completion date, are being met as the Southwest Grease & Oil Company, of Wichita, Kans., moves rapidly ahead with the development of their new, modern plant No. 2. This new plant, involving 28,000 sq. ft. of floor space, is located at the southeast corner of Wichita and Waterman Streets, adjacent to their present plant location.

Wichita, geographically the center of the United States, was chosen as the location for the new plant as opposed to off-site location, because in the opinion of the company's management, such location better permitted nation and world-wide distribution and more uniform control of product quality. Present plans call for the separate, though integrated, operation of these facilities, which upon completion will increase lubricant production capacity by 36,000,000 pounds, or 35 per cent over existing facilities.

H. A. Mayor, president of this fast growing independent, custom manufacturing, lubricant business, states the new plant No. 2 is needed to supply the increased demand for products originating from their customers. He firmly believes that the future looks good for the "House of Grease," and accordingly authorized this capital expenditure in excess of $250,000.

New Bulletin on Moly-Sulfide Additive Available

"Moly-Sulfide Lubricant Additive," a new twelve-page illustrated bulletin explaining Moly-Sulfide's function as a lubricant additive and describing commercial uses, has been issued by Climax Molybdenum company.

Designed especially for lubrication engineers, the bulletin summarizes the lubricating characteristics of Moly-Sulfide-containing lubricants as demonstrated by such standard tests as the Shell 4-Ball EP test, Falex anti-weld test and the Timken test. Data given show that Moly-Sulfide additive lowers wear rates of metal surfaces under extreme conditions, increases load capacity and extends the life of lubricants.

The bulletin presents technical information on Moly-Sulfide's chemical and physical properties and the relation between its laminer crystal structure and its performance in lubrication. Typical analyses of Climax Moly-Sulfide are also given.

Copies of the bulletin, designated Bulletin Lu-6, are available on request from Climax Molybdenum company, Dept. L, 500 Fifth Avenue, New York 36, N. Y.

Expanded Agricultural Research by Shell

Shell Development Company has announced plans for a million-dollar expansion program for its Modesto agricultural research center.

Dr. H. Gershinowitz, president, released the information, stating that plans provide for a large increase in facilities at the Modesto

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laboratory, located on Stoddard Road near the town of Salida.

Construction is scheduled for completion in the fall of 1957. About one million dollars will be spent for new buildings and services. Six major new laboratories and office buildings will be added to the present group.

The Los Angeles firm of Austin, Field & Fry have been selected as the architects and Jack Evans, designer of Disneyland gardens, is the landscaping consultant. The design features an open, campus-like plot plan selected for functional reasons. One-story buildings predominate, and the construction is of the prefabricated, lift-up type, but tied in with the existing buildings through the wide use of red brick features.

According to Dr. Gershinowitz, Shell will bring more than fifty families into the Modesto area from Denver and other Shell laboratory locations. A total staff of more than 100 people will be employed representing a yearly payroll in excess of a million dollars.

When completed and fully staffed, the laboratory is expected to be the outstanding agricultural research center in the western United States.

Biological research will be under the direction of Dr. Roy Hansberry, present Modesto laboratory manager. A chemical research group will be under Dr. K. E. Marple, presently manager of Shell's Denver laboratory.

McAllister Will Administer

S. H. McAllister, director of Shell Development's agricultural research division, will administer the two groups, together with a smaller one for products application research under Dr. E. F. Feichtmeir.

Shell's pioneering efforts in the agricultural field are well known. The firm was among the first manufacturers to produce fruit tree spray oils on the West Coast. They built the first high-pressure synthetic ammonia plant west of the Mississippi near Pittsburg, California, in 1929. Output of this plant was first sold as industrial ammonia and ammonium sulphate fertilizer.

In 1932, the first experimental work was done toward the direct application of anhydrous ammonia into irrigation water. This process, known as Shell Nitrogation Serv-

USED DRUM RACKS WANTED

An Eastern grease manufacturer is desirous of buying used 55 gallon drum racks, with double or single openings, length of racks to range from 8 ft. to 20 ft. in length, 4 tier high, complete with rails for drum supports and "X" braces. Reply to NLGI, SPOKESMAN, Box No. 12-1.

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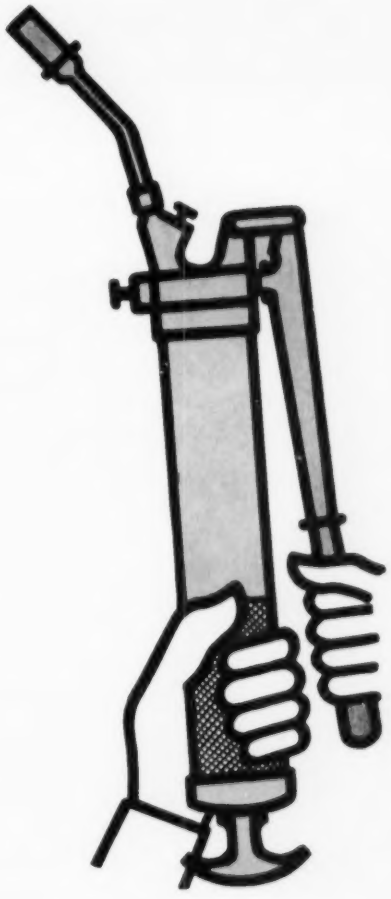

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H-14

HARCHEM DIVISION
WALLACE & TIERNAN INC
SUCCESSOR TO W. C. HARDESTY CO., INC.
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ice®, was commercially introduced in 1934. And in 1939 experimental work was begun on the direct injection of ammonia into the soil, a process which was introduced commercially in 1942 as Shell Nitrojection Service®.

In 1938 Shell entered the insecticide and spray oil business with products under their own label. At the same time research was initiated at Shell Oil Company's Martinez refinery and Shell Development's research center at Emeryville, California, to seek new products and applications in the agricultural field.

In 1944 Shell introduced the first really effective nematocidal soil fumigant, D-D®. Revolutionary developments in the field of agricultural chemicals led to the realization of the need for increased research and that same year plans were initiated for the purchase of an experimental farm and the construction of the present agricultural research laboratory at Modesto.

Acquired Hyman Company

Six years later (1952) Shell acquired the facilities of Julius Hyman Company at Denver, including chemical and entomological research labs and manufacturing facilities for production of the chlorinated insecticides, aldrin and dieldrin. Subsequently, the firm developed the insecticides endrin and Phosdrin and the nematocide Nemagon.

In 1953 a second Shell Ammonia plant went on stream at Ventura, California. A new plant for the production of urea, the first on the West Coast, has just been completed to add to the firm's line of fertilizers which includes ammonium phosphate, diammonium phosphate and triple super phosphate.

ASTM Special Technical Publication Announced

The American Society for Testing Materials has published a booklet titled "Methods for Reducing the Effect of Barometric Pressure in Measurement of Octane Number." The information in this publication was prepared as a joint undertaking of the American Petroleum Institute, the American Society for Testing Materials, and the National Bureau of Standards. It was presented before the Research Division on Combustion Characteristics of ASTM Committee D-2 on Petroleum Products and Lubricants by Bruno R. Siegel, formerly guest worker, National Bureau of Standards and presently with the Sinclair Research Laboratories, Inc., Harvey, Illinois.

Knock ratings made by the ASTM Motor, Research and Aviation methods are affected by barometric pressure. Earlier experiments at the National Bureau of Standards established the magnitude of rating variations in pressure range of 21.0 to 30.0 in. of mercury, and indicated that some means of resolving the effect of barometric pressure on octane rating was needed. As a result of the earlier findings, pressurized induction and exhaust systems

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were tested in the altitude chamber tests herein reported. While these schemes apparently would solve the problem, they were also beset with mechanical and operating difficulties. This prompted a third series of altitude chamber tests, in which inlet temperature and compression ratio were adjusted in combination to produce more uniform compression temperature-density relationships regardless of barometric pressure. The final results are presented in the form of tables of empirically determined operating conditions that will lead to substantially the same octane number when operated at any atmospheric pressure between 21.0 and 30.5 in. of mercury absolute.

The paper is of particular interest to those concerned with the combustion of fuels in knock test engines. Recent improvements in the ASTM methods for engine rating of fuels were made on the basis of data presented in this book.

Copies of this publication may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., at $1.50 each.

Gulf Releases New Oil Industry Story

Gulf Oil Corporation is now distributing a booklet entitled, "The Industry Nobody Really Knows," aimed at giving consumers of all petroleum products a more realistic understanding of how the oil industry actually gets its job done. The story is told in terms of the individual experiences of independent operators who have only a contractual relationship with any major oil company. The publication separates fact from myth in explaining how oil men who comprise "the largest industrial enterprise ever known," carry on their business.

Written by Craig Thompson, free-lance writer and author, the collection of facts for this story involved more than 8,000 miles of travel and literally hundreds of hours of interviews with persons ranging from lease buyers, royalty

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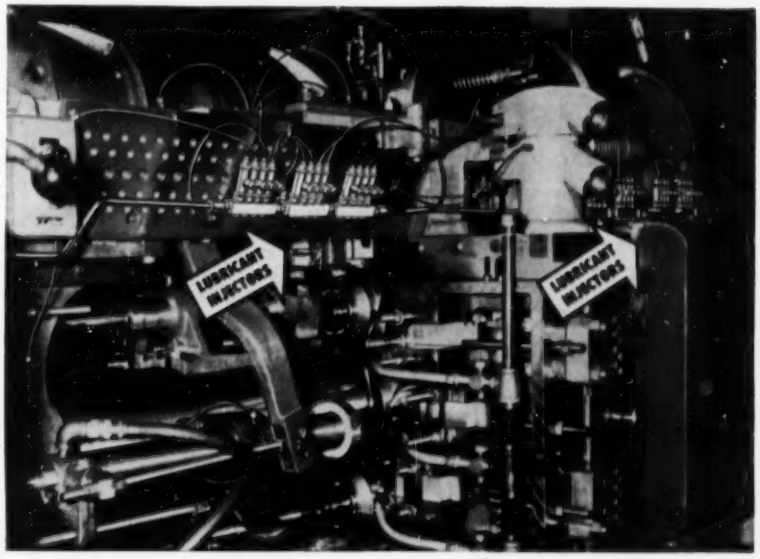

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owners, ranchers, truckers, and jobbers to junk buyers, bankers, producers, and service station owners, among others.

"The mental picture of the large oil company as a sort of gigantic octopus feeding on the little fellows is a myth," Mr. Thompson says, pointing out and refuting three other myths about this business. These, he says, are that ownership of an oil well automatically makes a man a millionaire, that oil millionaires are created by a so-called tax privilege known as percentage depletion; and that the oil industry is dominated and controlled by a few big companies.

This comprehensive story of the oil industry deals with many facets of this industry which until now have been disclosed largely only within the industry. It presents a dramatic picture of what might be termed the disintegration of an integrated industry.

The oil industry has been undergoing a process of disintegration that is still going on, according to this booklet. In divesting themselves of many functions the major oil companies have created numerous opportunities for small and middling business men. For example, Gulf's Houston production division does business with some 251 drilling operators and well servicing companies. A list of 154 additional firms makes a specialized contribution to Gulf's production needs. Included here are such diverse companies as machine shops, pest control companies, painting contractors, tank builders, and automotive dealers. Back of these businesses are a number of American success stories which are outlined in the booklet.

Alpha Molykote Issues New Testing Bulletin

A new testing machine for lubricants is described in Bulletin 106, just issued by The Alpha Molykote Corporation, Stamford, Connecticut.

The equipment is designated Model LFW-1 and is designed to test both bonded coating and liquid lubricants. In operation, a stationary rectangular block is pressed with a predetermined load against a rotating Timken® ring. Resulting friction is indicated throughout the test by a dial indicator and a counter counts the number of revolutions of the specimen. Tests are based on either the reaching of a pre-selected friction maximum, or the reaching of a pre-selected temperature value.

In the bulletin the equipment is pictured and its operation is diagrammatically visualized. Complete specifications in both the English and Metric systems are included.

Copies are available from The Alpha Molykote Corporation, Stamford, Connecticut.

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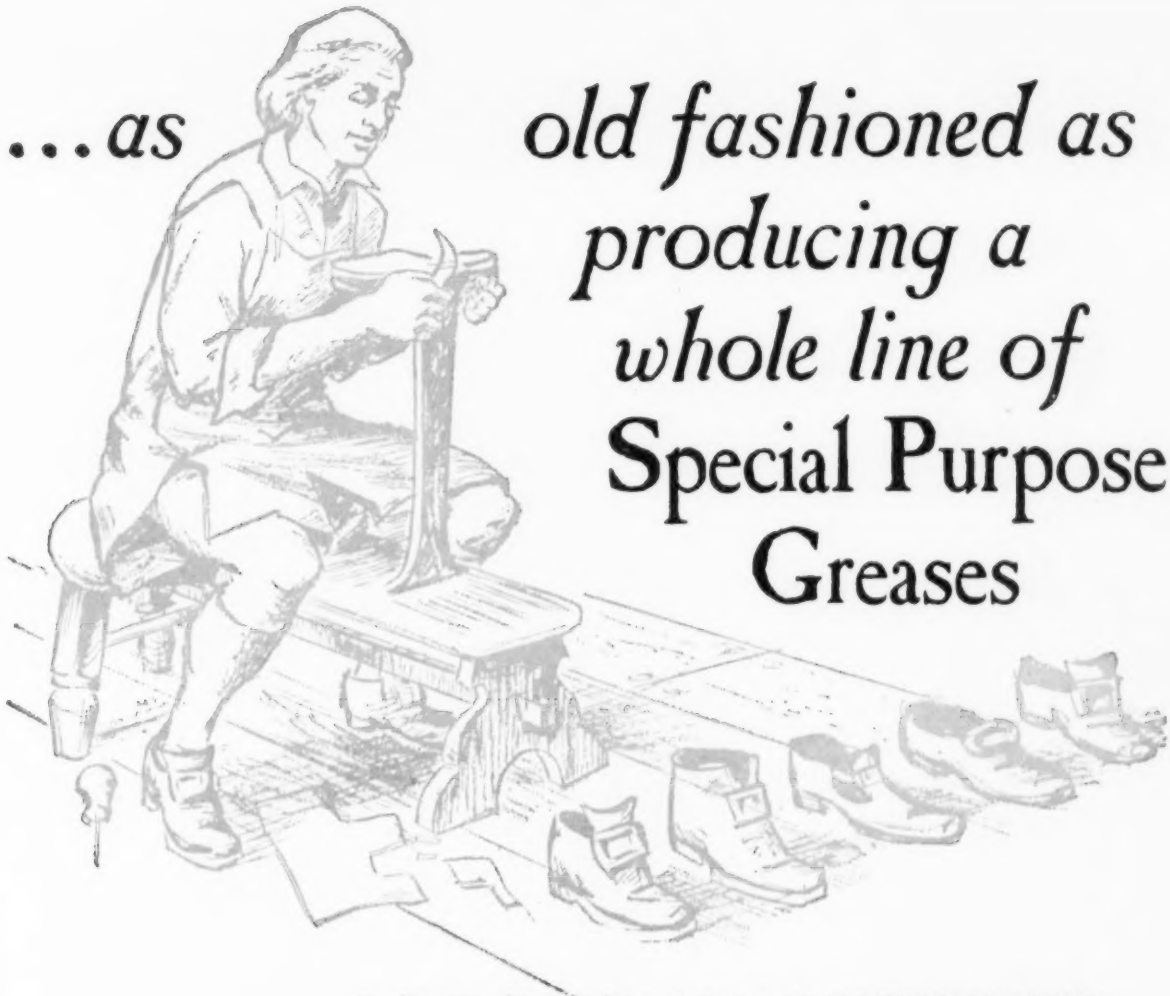

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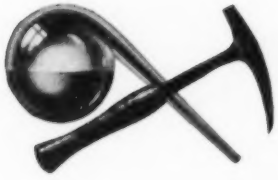
* *Foote lithium chemicals are used as the base for a truly multipurpose grease that combines water resistance with effective lubrication in service at temperatures from —60°F. to over 300°F., along with other important qualities.*



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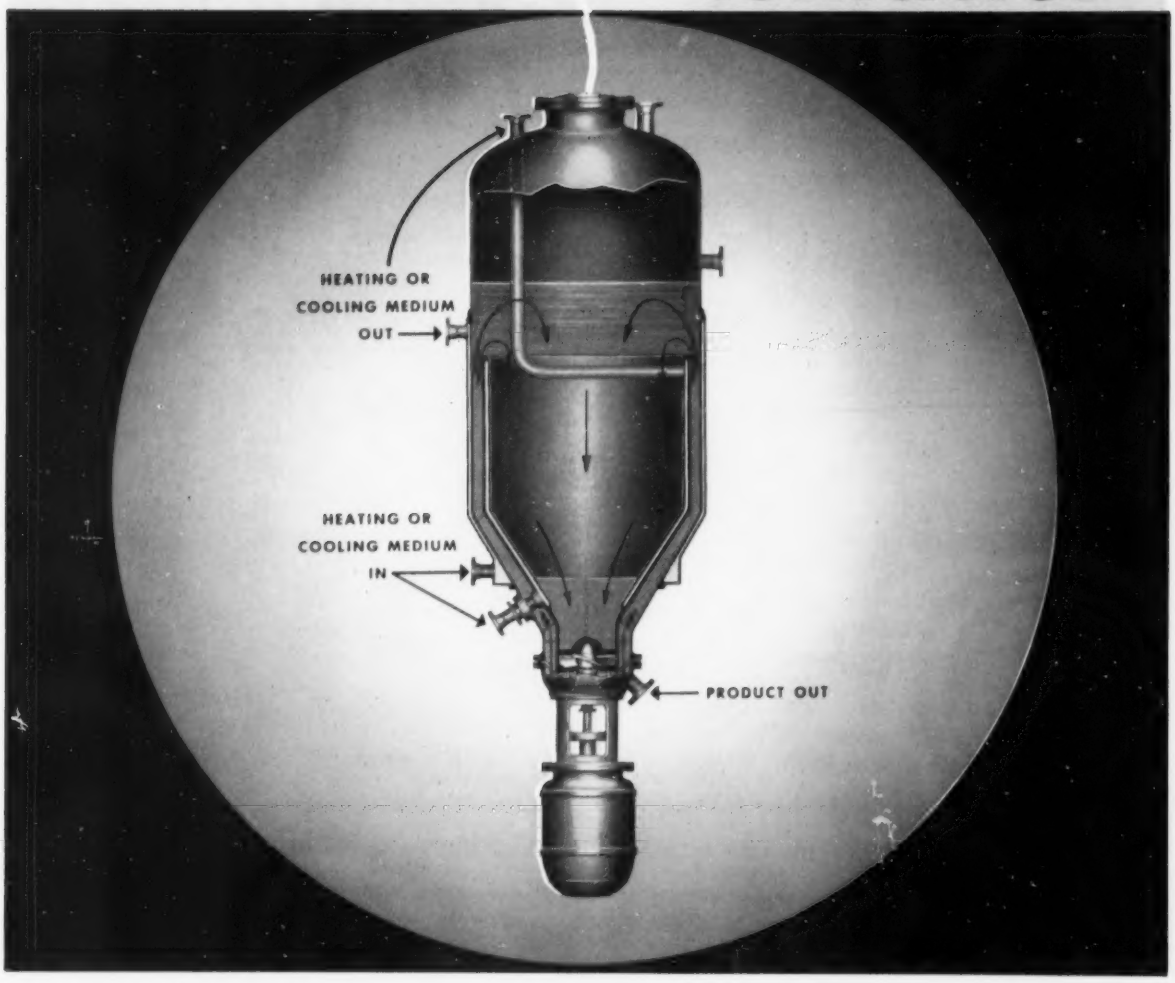

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